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02-Feb-26

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**Subject:** SUBTEL, Chile (Resolution 737) Certification Compliance 2026  
**Commercial Name:** Forerunner 265

	Información (Information)
<b>Tipo de equipo (Equipment type)</b>	Portable Digital Transceiver
<b>Marca (Brand)</b>	Garmin 
<b>Modelo (Model)</b>	A04452
<b>Tecnología o modulación (Technology or modulation)</b>	ASK for NFC / GFSK for ANT/ GFSK for BLE/ GFSK for BTBR / $\pi/4$ -DQPSK, 8DPSK for BTEDR / DSSS for 802.11b / OFDM for 802.11g/n
<b>Frecuencias (Frequencies)</b>	13.56 MHz / 2402-2480 MHz / 2402-2480 MHz / 2402-2480 MHz / 2402-2480 MHz / 2412-2462 MHz
<b>Ganancia de antena (dBi) (Antenna gain (dBi))</b>	ANT 1.13 dBi / BLE 1.13 dBi / 802.15.1 1.13 dBi / 802.15.1 1.13 dBi / 802.11b/g/n 1.13 dBi
<b>P.i.r.e. (E.I R P.)</b>	-26.54dBm, 0.002mW / 2.68 dBm, 1.85mW / 2.67 dBm, 1.85 mW / 11.32 dBm, 13.15 mW / 10.42 dBm, 11.02 mW / 18.91 dBm, 77.80 mW
<b>Módulos (Modules)</b>	NFC, ANT, BLE, BTBR, BTEDR, WiFi

As all measurements for NFC are made in radiated mode to comply with the field strength limits, gain information is not required to be noted in the reports or any additional documentation.

Declaration of Conformity Statement: the equipment previously identified complies with the provisions established in the Technical Standard for Small Range Equipment, approved by Exempt Resolution No. 1,985 of 2017, of the Undersecretary of Telecommunications.

Declaración de conformidad: El equipo anteriormente identificado cumple con las disposiciones establecidas en la Norma Técnica para Equipos de Corto Alcance, aprobada mediante la Resolución Exenta N° 1.985 de 2017, de la Subsecretaría de Telecomunicaciones.

## FCC/ISED Test Report

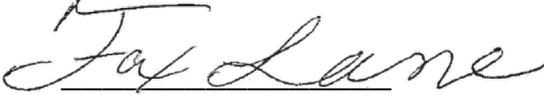
**Prepared for:**           **Garmin International, Inc.**

**Address:**               **1200 E. 151<sup>st</sup> Street**  
                                  **Olathe, Kansas, 66062, USA**

**Product:**               **A04452**

**Test Report No:**       **R20220901-21-E2B**

**Approved by:**

  
**Fox Lane,**  
**EMC Test Engineer**

**DATE:**                 **December 6, 2022**

**Total Pages:**         **38**

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**REVISION PAGE**

Rev. No.	Date	Description
0	18 November 2022	Issued by – FLane Reviewed by KVepuri Prepared by GLarsen, FLane
A	2 December 2022	Corrected Antenna Gain - FL
B	6 December 2022	Removed Antenna Gain - FL



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## 1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section:

### FCC Part 15.247

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15
- (2) ISED RSS-Gen, Issue 5
- (3) ISED RSS-247, Issue 2

APPLIED STANDARDS AND REGULATIONS		
Standard Section	Test Type	Result
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(b)(1) RSS-247 Issue 2 Section 5.1(b)	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.1 (b)	Bandwidth	Pass
FCC Part 15.247(a)(1)(iii) RSS-247 Issue 2 Section 5.1(d)	Frequency Hopping System	Pass
FCC Part 15.209 RSS-Gen Issue 5, Section 7.3	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 5, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 5.5	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass

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## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

#### Summary and Operating Condition:

<b>EUT</b>	A04452
<b>IC</b>	1792A-04452
<b>FCC ID</b>	IPH-04452
<b>EUT Received</b>	3 October 2022
<b>EUT Tested</b>	3 October 2022- 7 November 2022
<b>Serial No.</b>	3426283485 (Radiated Measurements) 3426283465 (Conducted Measurements)
<b>Operating Band</b>	2400 – 2483.5 MHz
<b>Device Type</b>	<input type="checkbox"/> GMSK <input type="checkbox"/> GFSK <input checked="" type="checkbox"/> BT BR <input type="checkbox"/> BT EDR 2MB <input type="checkbox"/> BT EDR 3MB <input type="checkbox"/> 802.11x
<b>Power Supply / Voltage</b>	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: AQ27A-59CFA GPN: 362-00118-00 (Representative Power Supply)

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

### 2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

For BTBR Transmissions:

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

### 2.3 DESCRIPTION OF SUPPORT UNITS

None

## 3.0 LABORATORY AND GENERAL TEST DESCRIPTION

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### 3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)  
 4740 Discovery Drive  
 Lincoln, NE 68521  
 A2LA Certificate Number: 1953.01  
 FCC Accredited Test Site Designation No: US1060  
 Industry Canada Test Site Registration No: 4294A-1  
 NCC CAB Identification No: US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of  $35 \pm 4\%$   
 Temperature of  $22 \pm 3^\circ$  Celsius



### 3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Review/Testing and Report
2	Blake Winter	Test Engineer	Testing
3	Grace Larsen	Test Engineer	Testing and Report
4	Ethan Schmidt	Test Technician	Testing

**Notes:**

All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

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### 3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
ETS EMCO Red Horn Antenna	3115	00218655	July 21, 2022	July 21, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preampfier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Rohde & Schwarz Preampfier*	TS-PR18	3545700803	August 22, 2022	August 22, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber***	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preampfier to antenna)*	MFR-57500	90-195-040	August 22, 2022	August 22, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

\*Internal Characterization

**Notes:**

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

### 3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMENTS

Measurement type presented in this report (Please see the checked box below):

#### Conducted

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

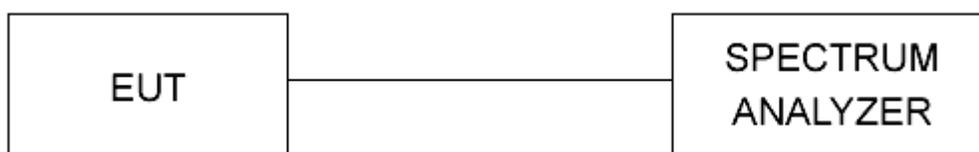


Figure 1 - Bandwidth Measurements Test Setup

#### Radiated

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

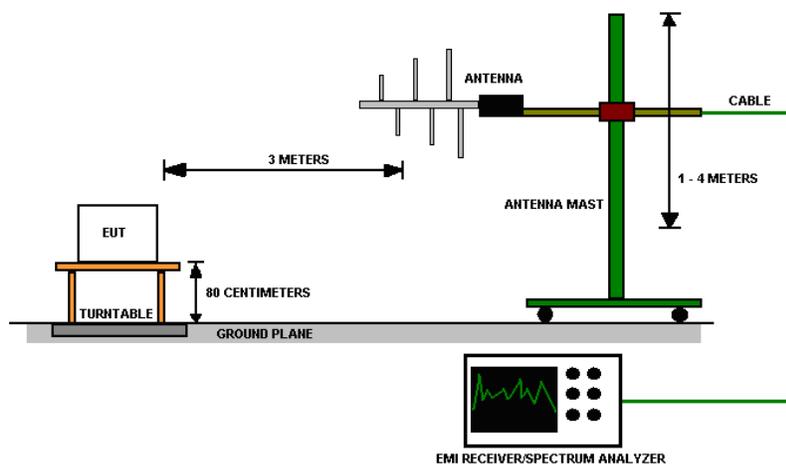


Figure 2 - Radiated Emissions Test Setup



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#### 4.0 RESULTS

##### DSS Radio Measurements

CHANNEL	Transmitter	Occupied Bandwidth (kHz)	20 dB Bandwidth (kHz)	AVERAGE OUTPUT POWER (dBm)	AVERAGE OUTPUT POWER (mW)	RESULT	No. of Hopping Channels	ON Time (µs)
							79	377
Low	Continuous	947.82	1117.0	9.86	9.68	PASS	Channel Separation (MHz)	Time of Occupancy (ms)
Mid	Continuous	935.81	1118.0	10.19	10.45	PASS		
High	Continuous	955.18	1117.0	9.98	9.95	PASS		

Occupied Bandwidth = N/A;  
Channel Separation Limit: > 2/3 \* 20 dB Bandwidth.

Peak Output Power Limit = 125mW;  
Time of Occupancy Limit < 0.4s;  
Time of Occupancy = ON Time \* # of transmissions over, period of time of occupancy = 0.000377\*32\*10 (See Figure 11 in appendix C) = 0.1264 s  
Period of Time of Occupancy = 0.4 \* # of Channels = 0.4 \* 79 = 31.6s

##### Unrestricted Band-Edge

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamental (dBuV)	Delta (dB)	Min Delta (dB)	Result
Low	Continuous	2400.00	70.617	116.706	46.089	30.0	PASS
Low	Hopping	2400.00	69.431	117.598	48.167	30.0	PASS
High	Continuous	2483.50	55.819	117.435	61.616	30.0	PASS
High	Hopping	2483.50	52.510	116.119	63.609	30.0	PASS

##### Peak Restricted Band-Edge

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit* (dBuV/m @ 3m)	Margin	Result
Low	Continuous	2390.00	54.220	Peak	73.98	19.76	PASS
High	Continuous	2483.50	56.236	Peak	73.98	17.744	PASS

\*Limit shown is the peak limit taken from FCC Part 15.209

##### Average Restricted Band-Edge

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)**	Measurement Type	Limit (dBuV/m @ 3m)*	Margin	Result
Low	Continuous	2390.00	42.169	Average	53.98	11.81	PASS
High	Continuous	2483.50	45.904	Average	53.98	8.076	PASS

\*Limit shown is the average limit taken from FCC Part 15.209  
See Sec 4.3 for more information on DCCF



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#### 4.1 OUTPUT POWER

**Test Method:** All the radio measurements were performed using the section 11.9.2.2.4 from ANSI C63.10.

**Limits of power measurements:**

**For FCC Part 15.247 Device:**

The maximum allowed peak output power is 125mW.

**Test procedures:**

Details can be found in section 3.4 of this report. See section 4.3 for Duty cycle used.

**Deviations from test standard:**

No deviation.

**Test setup:**

Details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the output power plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables below.
4. Compiled values can be found in the Results section, 4.0.

## 4.2 BANDWIDTH

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of bandwidth measurements:**

**For FCC Part 15.247 Device:**

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the bandwidth plots can be found in the Appendix C.
2. All the measurements were found to be compliant.



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### 4.3 DUTY CYCLE

**Test Method:**

All transmitter(s)/modulation(s) in this report are >98%, no duty cycle corrections were added

#### 4.4 RADIATED EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.5, 6.6

**Limits for radiated emissions measurements:**

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ( $\mu\text{V/m}$ )	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

**NOTE:**

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) =  $20 * \log * \text{Emission level } (\mu\text{V/m})$ .
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.



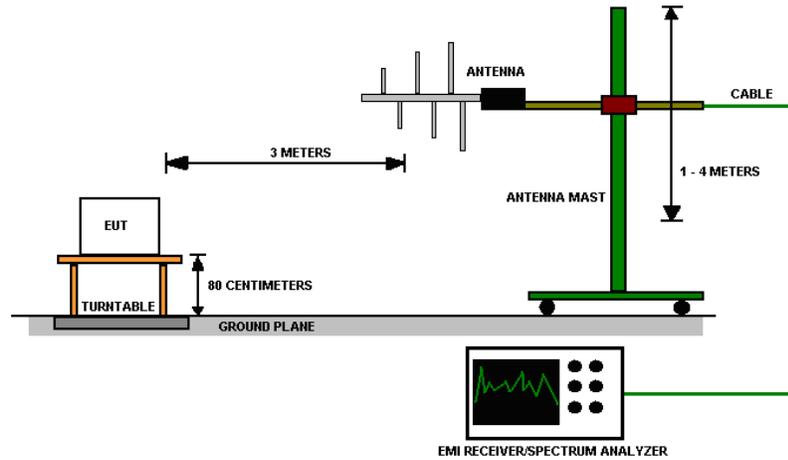
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**Test procedures:**

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

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**Test setup:**



**Figure 3 - Radiated Emissions Test Setup**

**NOTE:**

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

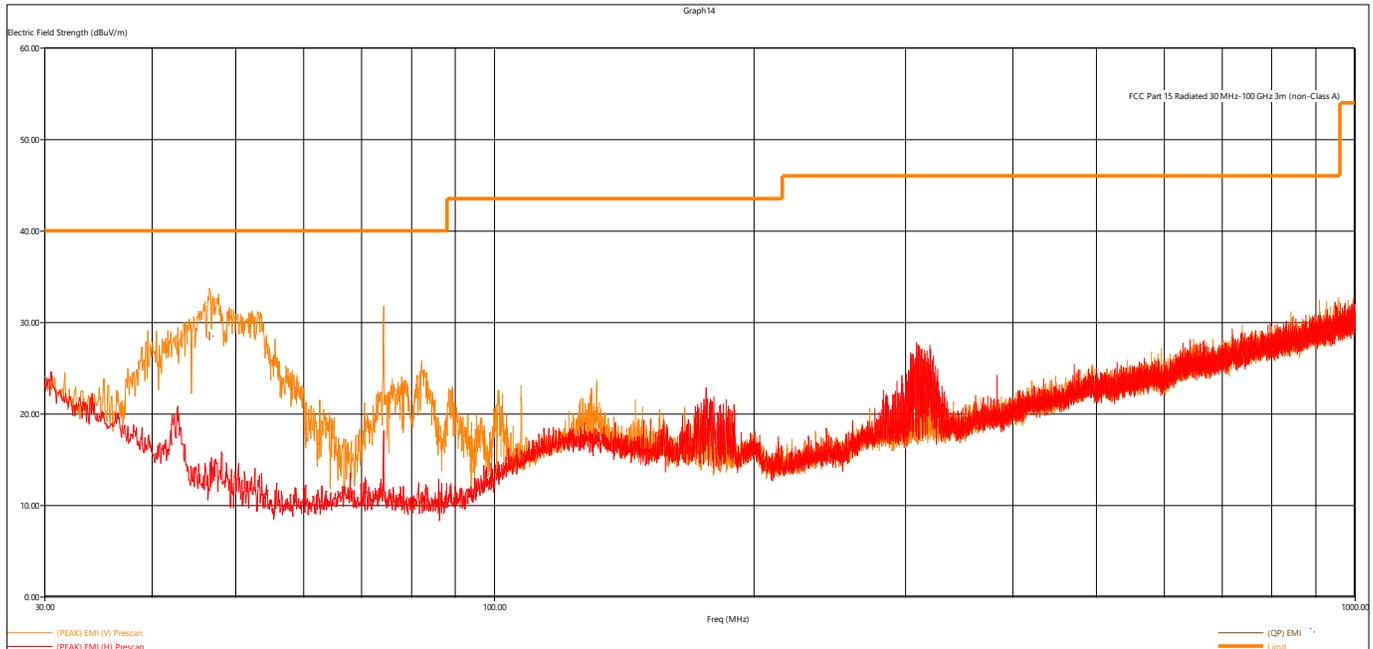
**Deviations from test standard:**

No deviation.

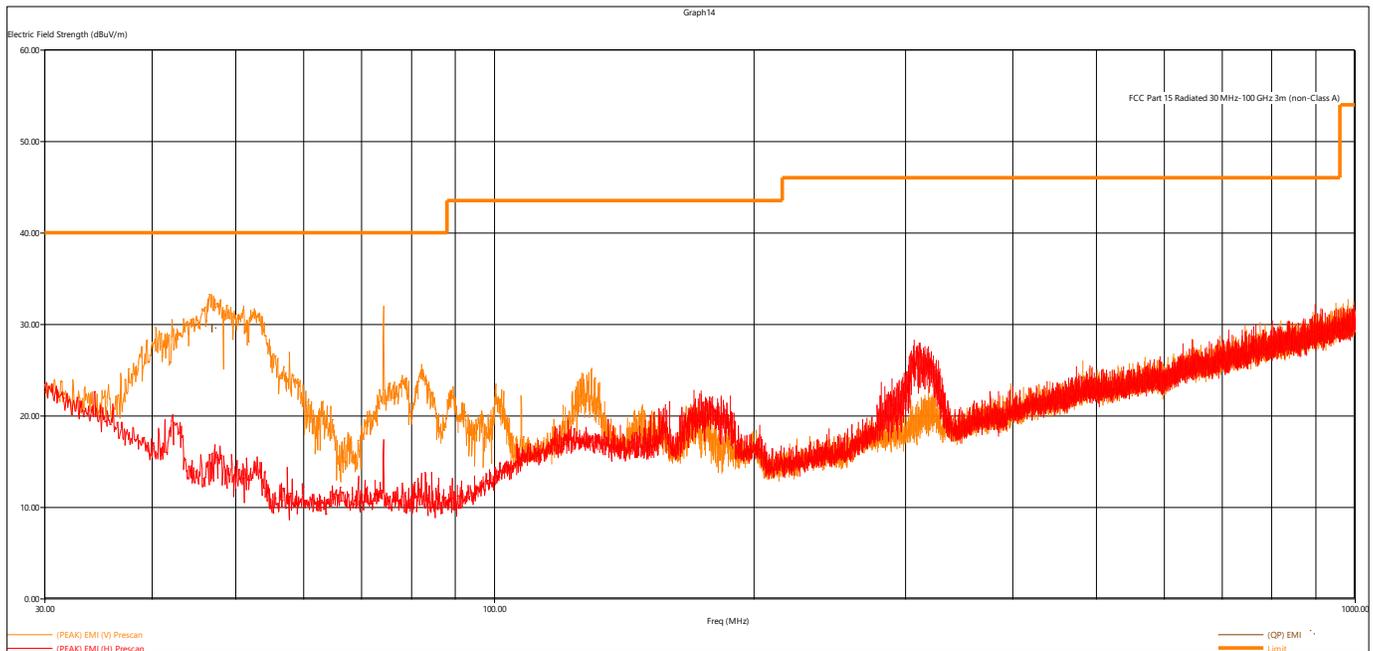
**EUT operating conditions**

Details can be found in section 2.1 of this report.

**Test results:**



**Figure 4 - Radiated Emissions Plot, Receive**



**Figure 5 - Radiated Emissions Plot, BTBR, Low Channel**

**REMARKS:**

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB).
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB).
3. The other emission levels were very low against the limit.
4. Margin value = Limit value – Emission Level.
5. Emissions found to be at least 10dB below limit line and were not reported.



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Quasi-Peak Measurements, BTBR								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
46.880640	29.56	40.00	10.44	106.00	227.00	V	Low	BTBR
46.431840	28.41	40.00	11.59	106.00	235.00	V	RX	

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above. All other measurements were found to be at least 6 dB Below the limit.

Peak Measurements, BTBR								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2402.064000	105.81	NA	NA	162.00	5.00	V	Low	BT BR
2440.082000	105.79	NA	NA	187.00	360.00	V	Mid	BT BR
2480.114000	106.20	NA	NA	172.00	3.00	V	High	BT BR
4803.862000	46.68	73.98	27.30	200.00	215.00	V	Low	BT BR
7206.342000	54.43	73.98	19.55	516.00	115.00	V	Low	BT BR
4880.268000	48.97	73.98	25.01	177.00	162.00	V	Mid	BT BR
7320.040000	55.37	73.98	18.61	473.00	150.00	V	Mid	BT BR
4960.100000	48.47	73.98	25.51	204.00	209.00	H	High	BT BR
7440.102000	53.17	73.98	20.81	498.00	154.00	V	High	BT BR

All other emissions found to be at least 6dB below limit line

Average Measurements, BTBR								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2402.064000	104.97	NA	NA	162.00	5.00	V	Low	BT BR
2440.082000	104.83	NA	NA	187.00	360.00	V	Mid	BT BR
2480.114000	105.09	NA	NA	172.00	3.00	V	High	BT BR
4803.862000	38.35	53.98	15.63	200.00	215.00	V	Low	BT BR
7206.342000	45.72	53.98	8.26	516.00	115.00	V	Low	BT BR
4880.268000	40.83	53.98	13.15	177.00	162.00	V	Mid	BT BR
<b>7320.040000</b>	<b>48.19</b>	<b>53.98</b>	<b>5.79</b>	<b>473.00</b>	<b>150.00</b>	<b>V</b>	<b>Mid</b>	<b>BT BR</b>
4960.100000	40.24	53.98	13.74	204.00	209.00	H	High	BT BR
7440.102000	44.98	53.98	9.00	498.00	154.00	V	High	BT BR

\*Average Levels Obtained from; Average Level = Peak Level + DCCF (For Emissions), for more information on DCCF see Sec 4.3  
All other emissions found to be below measurement sensitivity.



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#### 4.5 CONDUCTED SPURIOUS EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.7

**Limits of spurious emissions:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

**Test procedures:**

The highest emissions level was measured and recorded. All spurious measurements were evaluated to 20dB below the fundamental. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

None

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

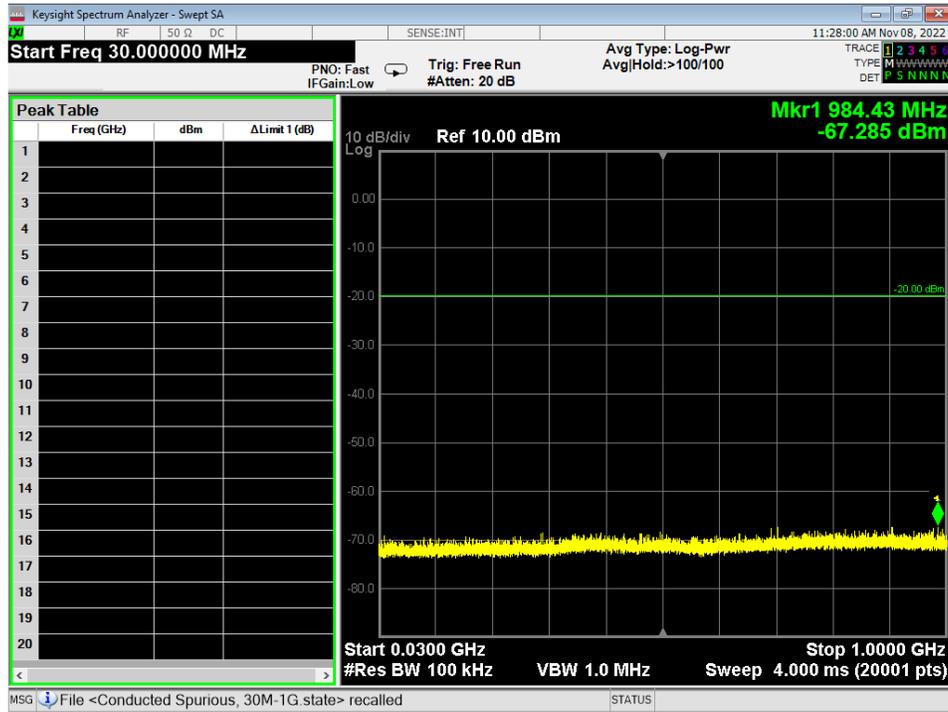


Figure 6 - Radiated Emissions Plot, BTBR, 30M – 1G

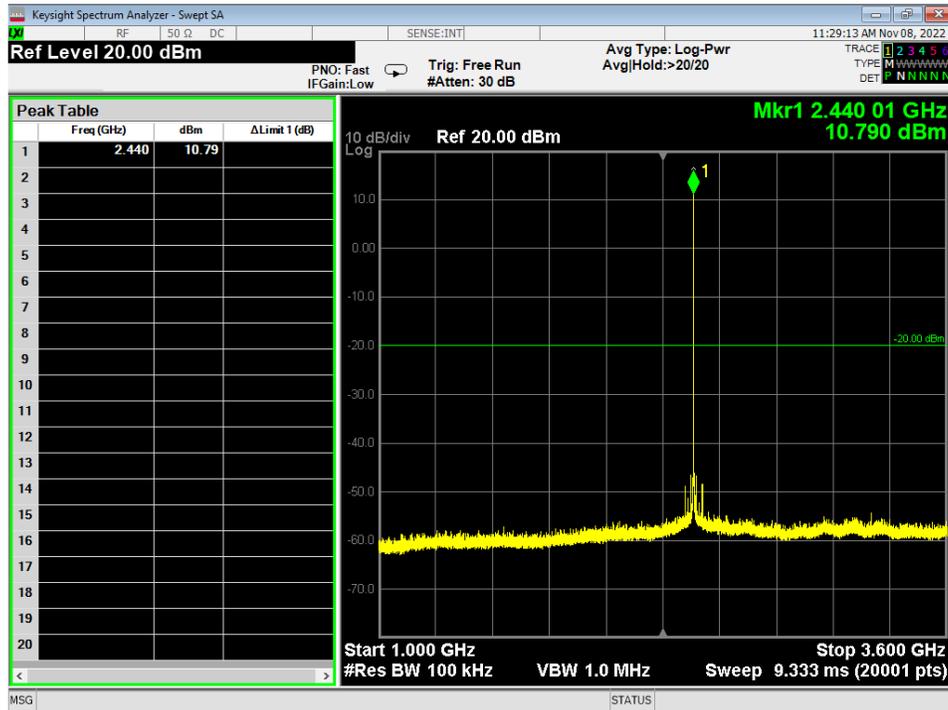


Figure 7 - Radiated Emissions Plot, BTBR, 1G – 3.6G

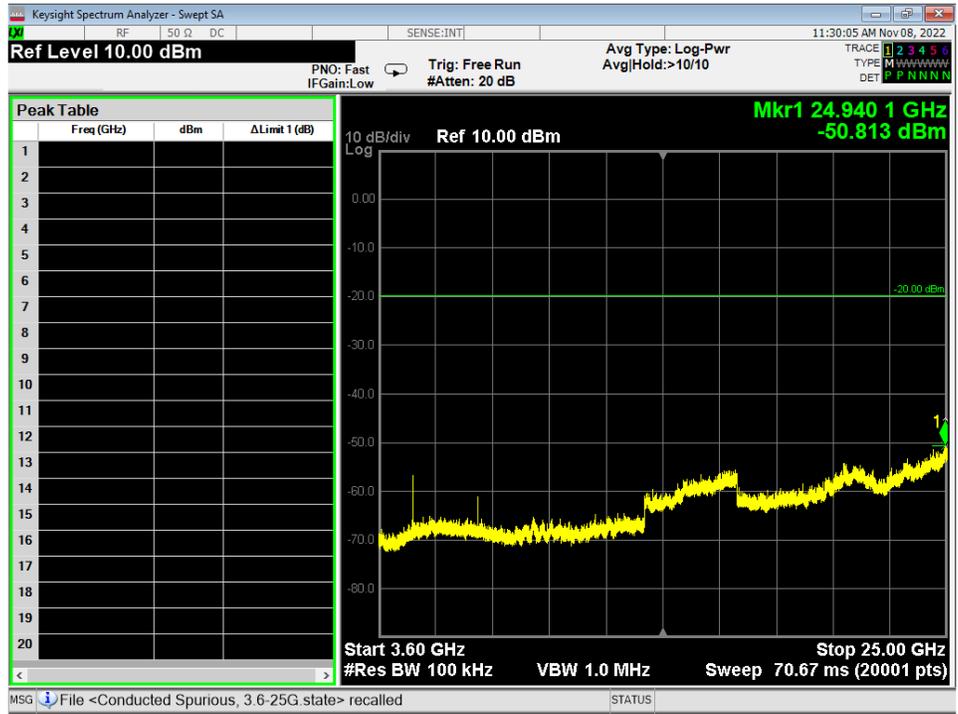


Figure 8 - Radiated Emissions Plot, BTBR, 3.6G – 25G

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#### 4.6 BAND EDGES

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10. Restricted band edges are using Sec 6.10.5.

**Limits of band-edge measurements:**

**For FCC Part 15.247 Device:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

**Test procedures:**

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.



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**Test results:**

**Pass**

Comments:

1. All the band edge plots can be found in the Appendix C.
2. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.

## 4.7 CONDUCTED AC MAINS EMISSIONS

**Test Method:** ANSI C63.10-2013, Section(s) 6.2

**Limits for conducted emissions measurements:**

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dB $\mu$ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

**Notes:**

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

**Test Procedures:**

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

**Deviation from the test standard:**

No deviation

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

Test Results:



Figure 9 - Conducted Emissions Plot, Line, TX



Figure 10 - Conducted Emissions Plot, Neutral, TX

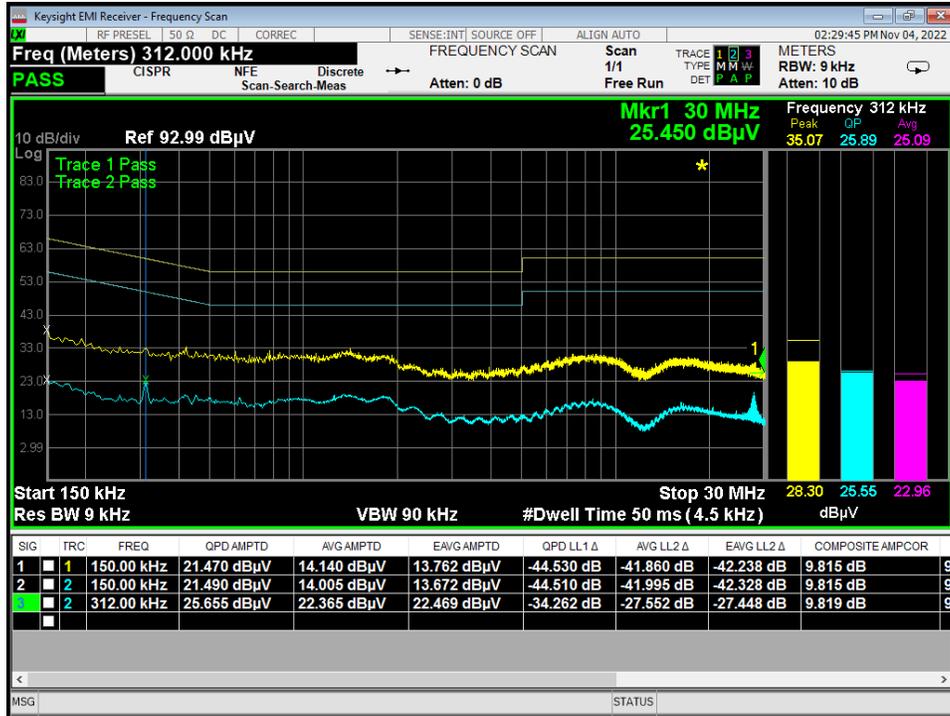


Figure 11 - Conducted Emissions Plot, Line, IDLE



Figure 12 - Conducted Emissions Plot, Neutral, IDLE



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Garmin International, Inc.

## APPENDIX A: SAMPLE CALCULATION

**Field Strength Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB $\mu$ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB $\mu$ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by taking the  $20 \cdot \log(T_{on}/100)$  where  $T_{on}$  is the maximum transmission time in any 100ms window.

## EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

$$EIRP \text{ (Watts)} = [\text{Field Strength (V/m)} \times \text{antenna distance (m)}]^2 / 30$$

$$\text{Power (watts)} = 10^{[\text{Power (dBm)}/10]} / 1000$$

$$\text{Voltage (dB}\mu\text{V)} = \text{Power (dBm)} + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$\text{Field Strength (V/m)} = 10^{[\text{Field Strength (dB}\mu\text{V/m)} / 20]} / 10^6$$

$$\text{Gain} = 1 \text{ (numeric gain for isotropic radiator)}$$

Conversion from 3m field strength to EIRP (d=3):

$$EIRP = [\text{FS (V/m)} \times d^2] / 30 = \text{FS} [0.3] \quad \text{for } d = 3$$

$$EIRP(\text{dBm}) = \text{FS}(\text{dB}\mu\text{V/m}) - 10(\log 10^9) + 10\log[0.3] = \text{FS}(\text{dB}\mu\text{V/m}) - 95.23$$

*10log( 10^9) is the conversion from micro to milli*

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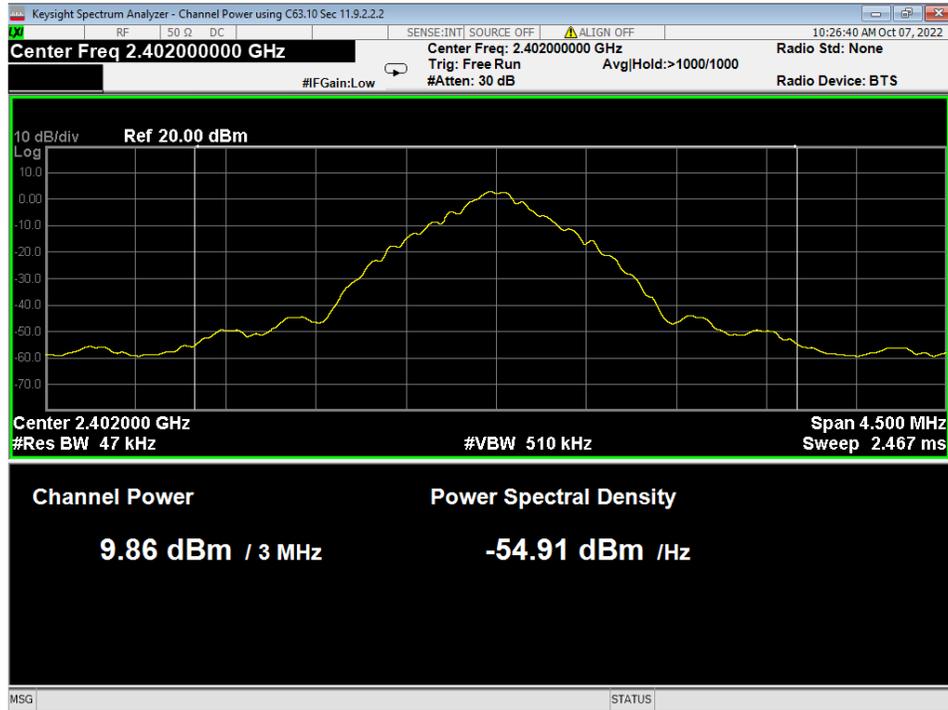
**APPENDIX B – MEASUREMENT UNCERTAINTY**

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

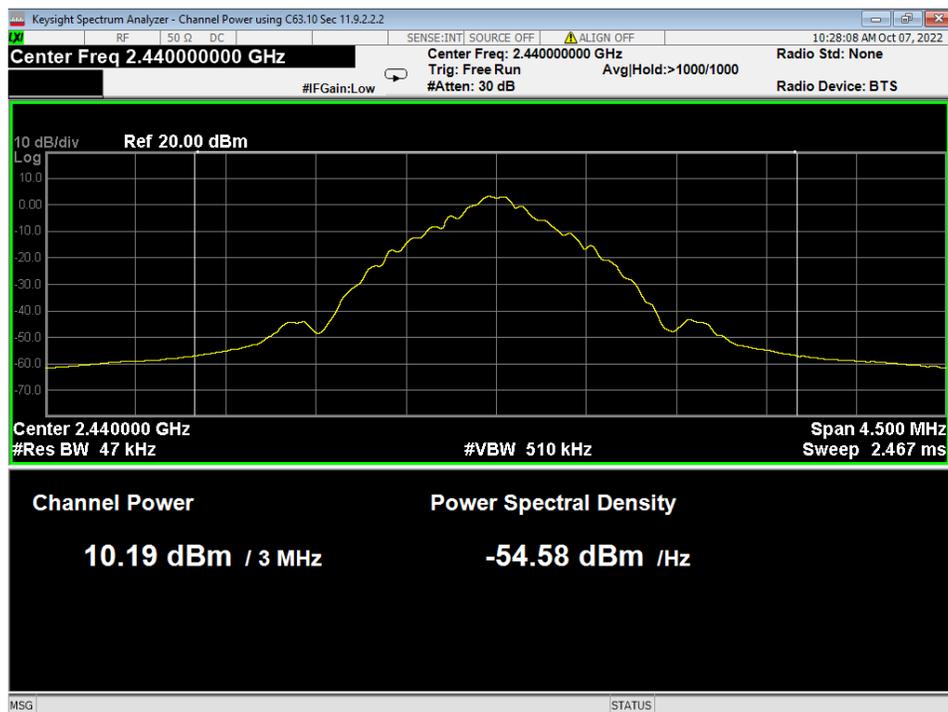
<b>Test</b>	<b>Frequency Range</b>	<b>Uncertainty Value (dB)</b>
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	150kHz – 30MHz	±3.03

Expanded uncertainty values are calculated to a confidence level of 95%.

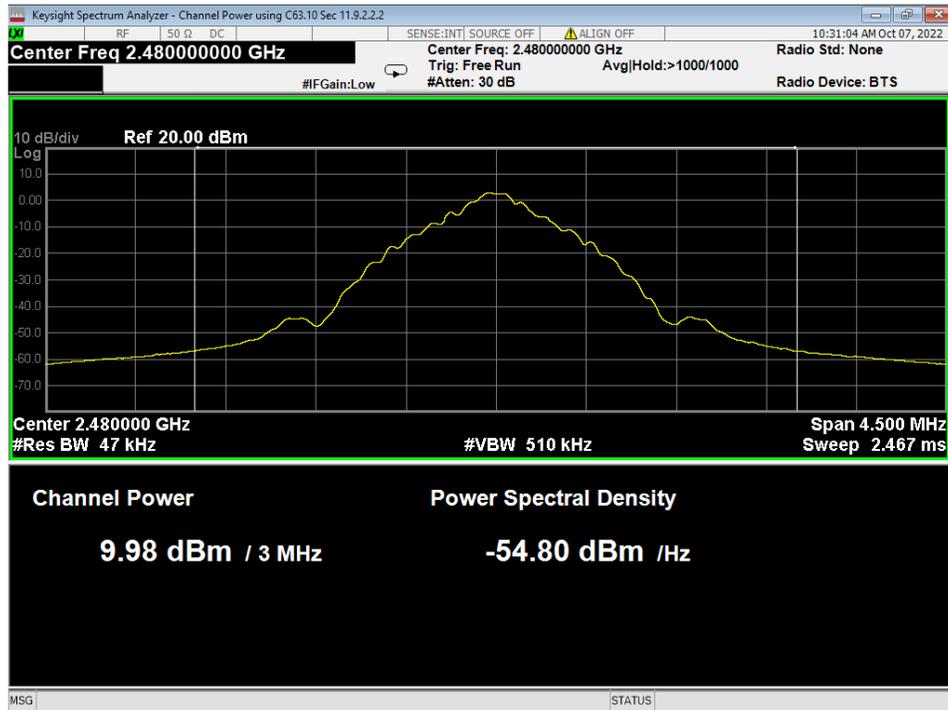
## APPENDIX C – GRAPHS AND TABLES



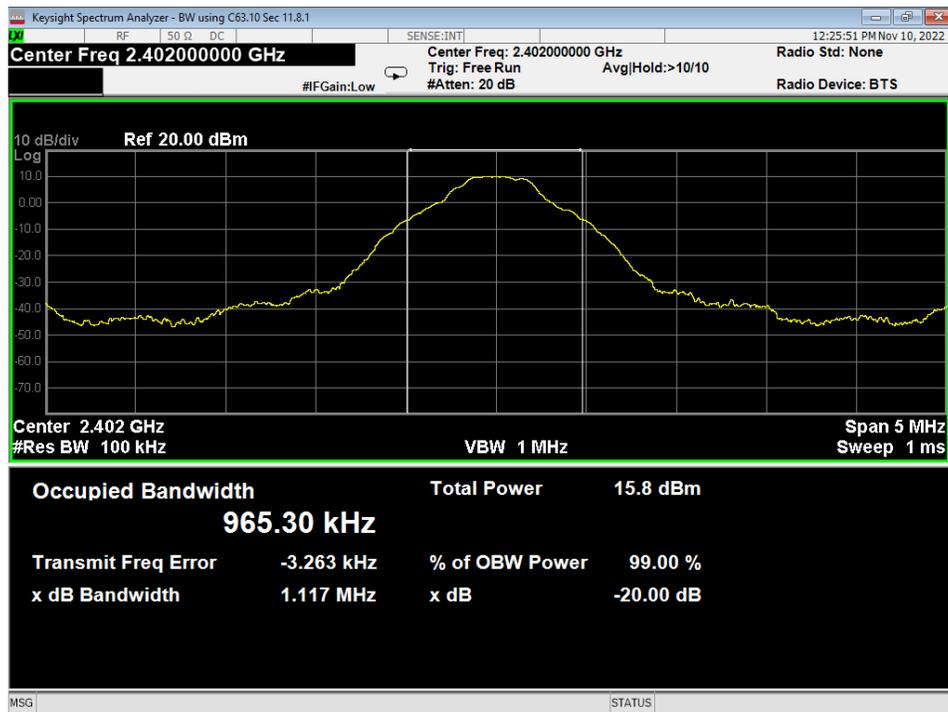
01 Average Power, Low Channel, BTBR



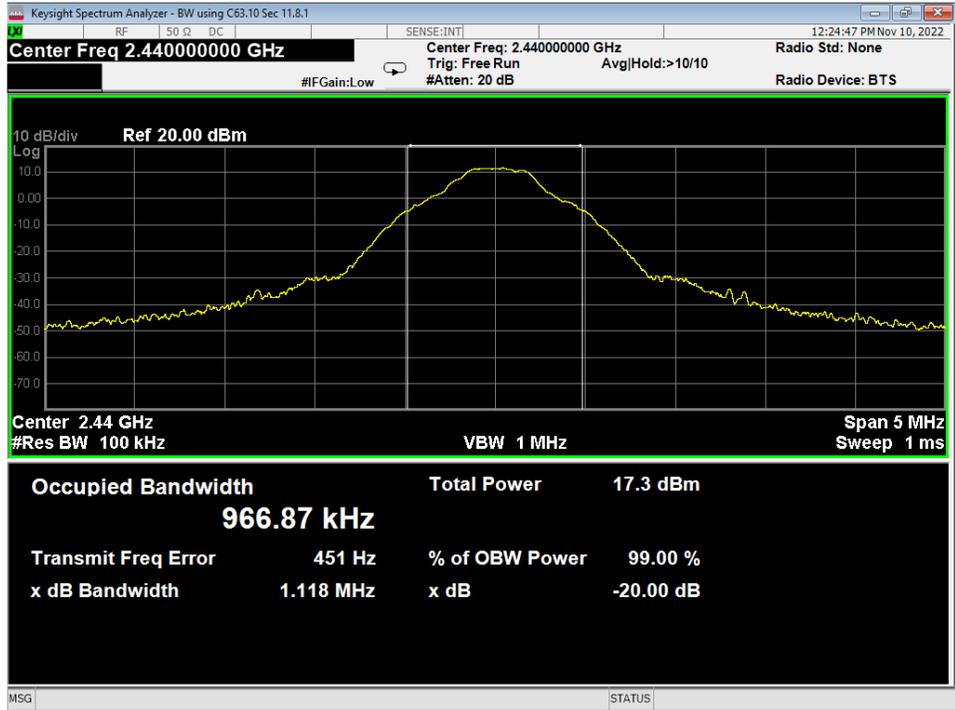
02 Average Power, Mid Channel, BTBR



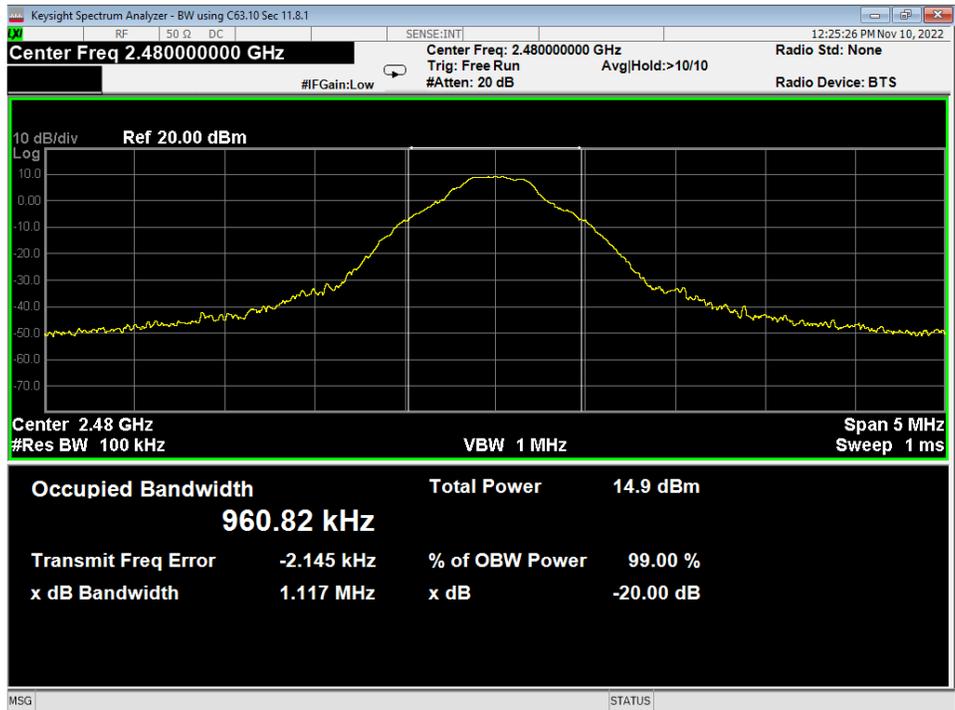
03 Average Power, High Channel, BTBR



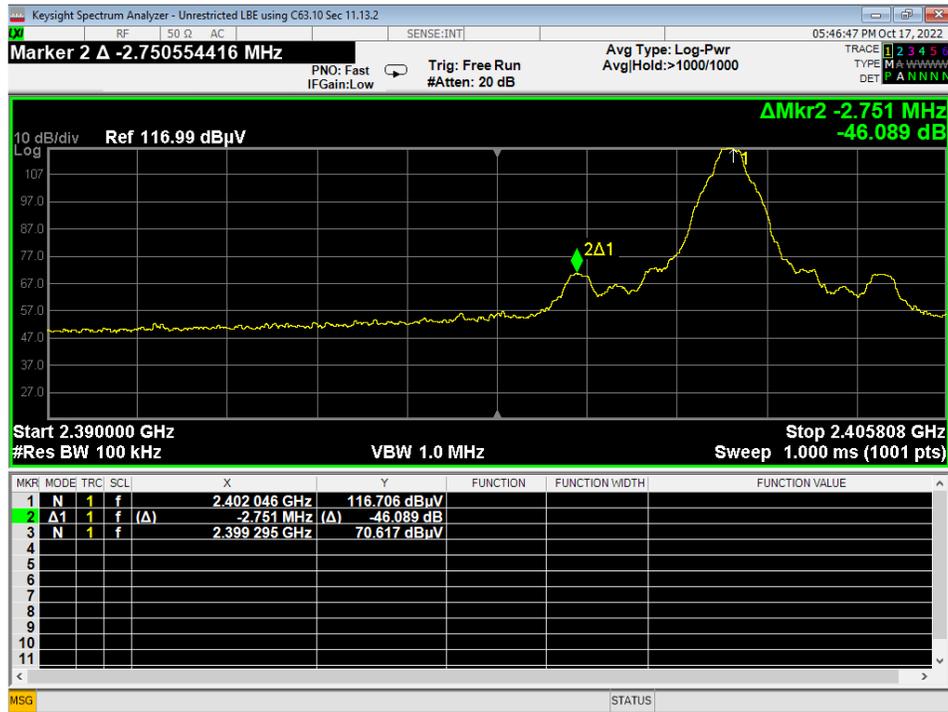
04 OBW-20dB, Low Channel, BTBR



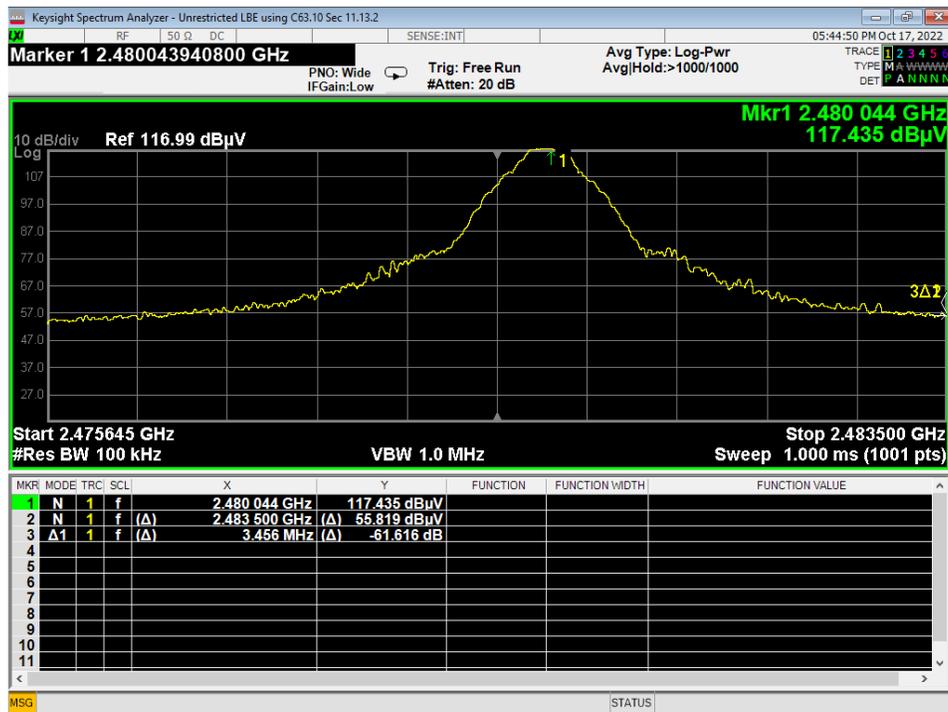
05 OBW-20dB, Mid Channel, BTBR



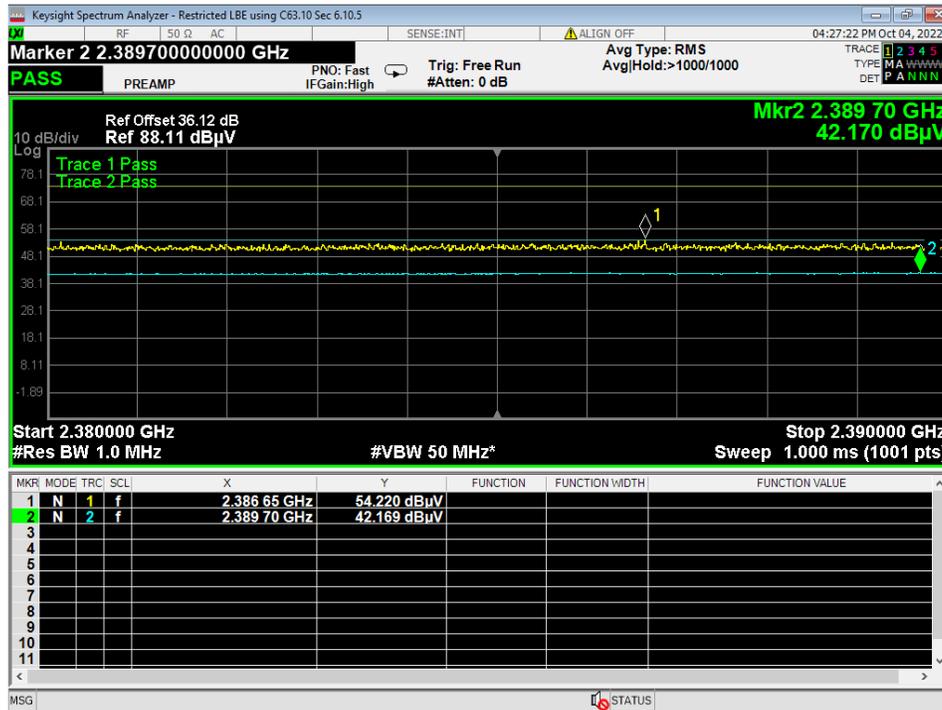
06 OBW-20dB, High Channel, BTBR



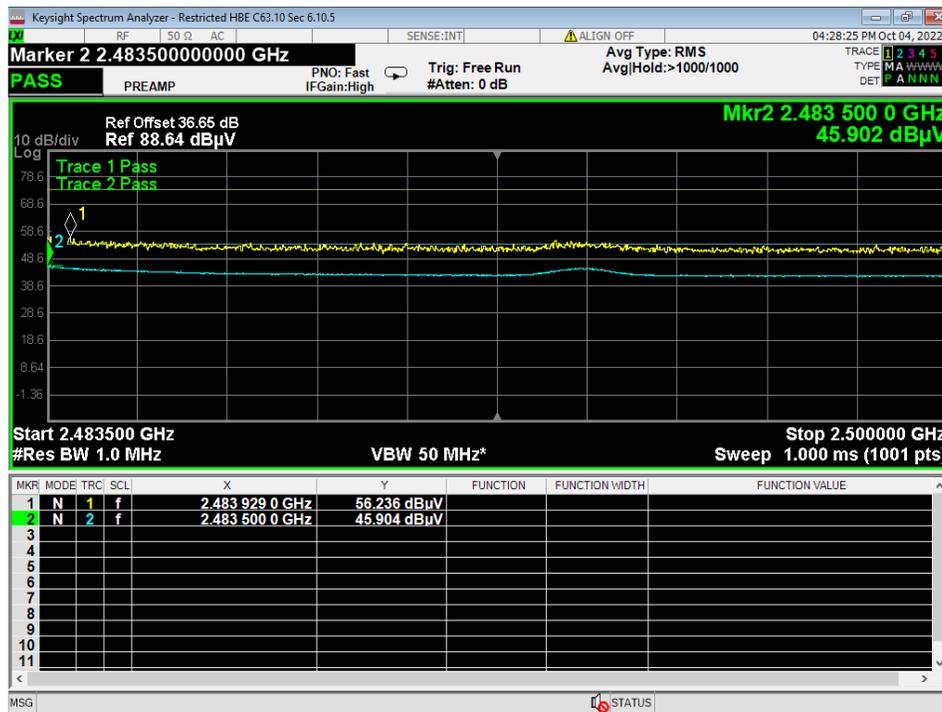
07 Lower Bandedge, Unrestricted, BTBR



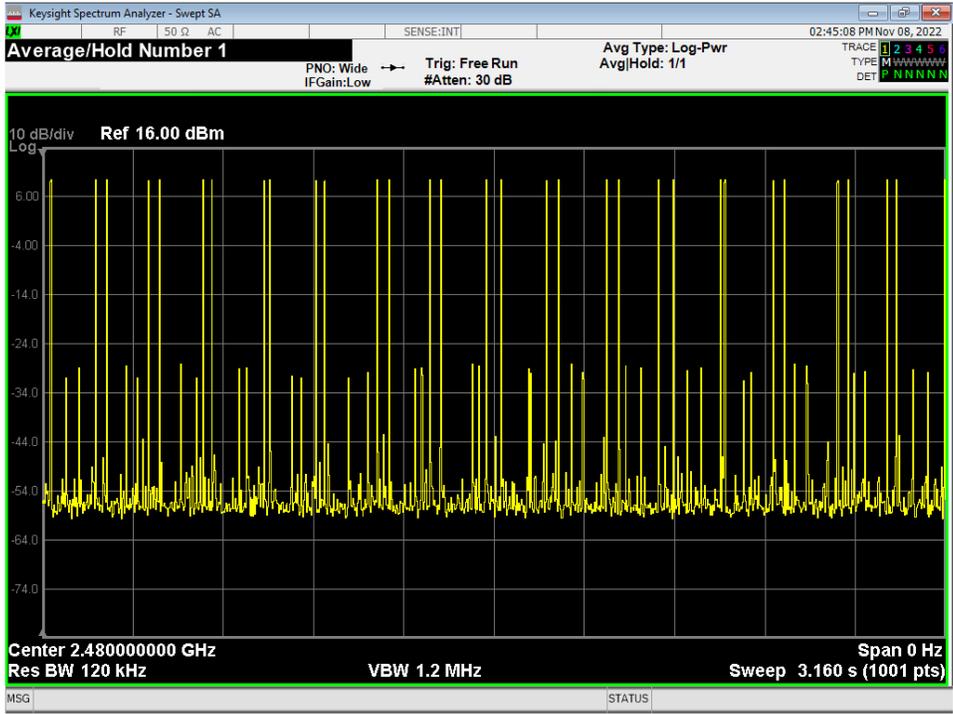
08 Higher Bandedge, Unrestricted, BTBR



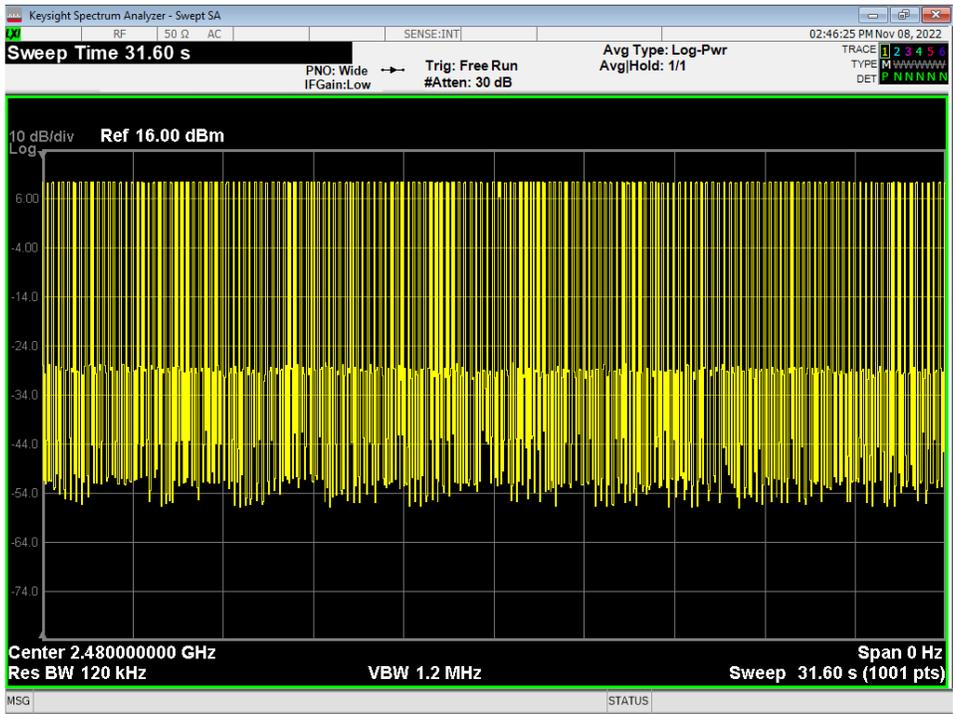
09 Lower Bandedge, Restricted, BTBR



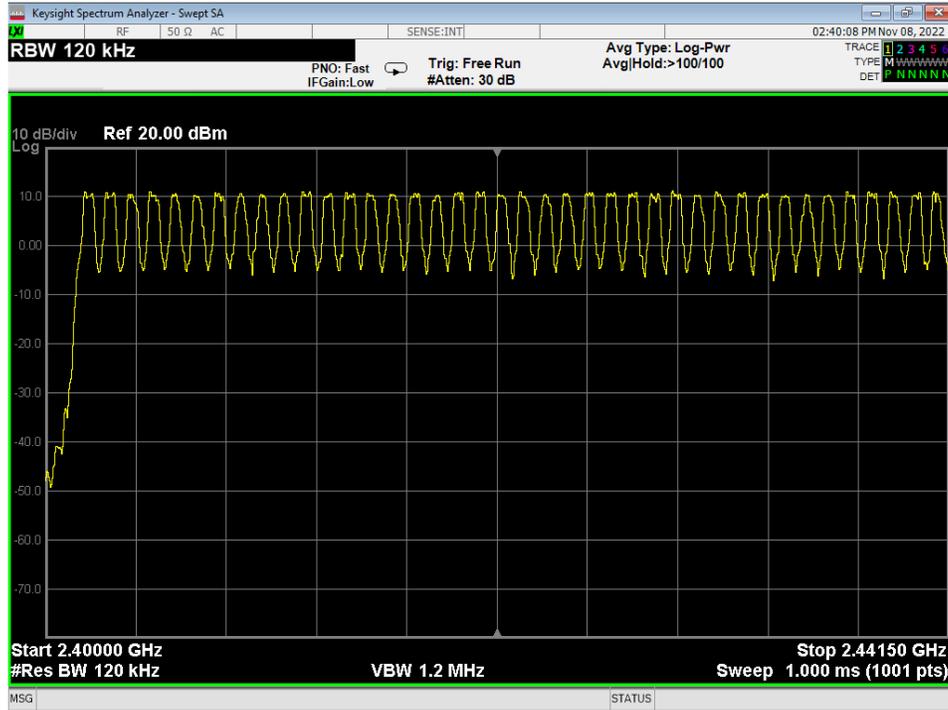
10 Higher Bandedge, Restricted, BTBR



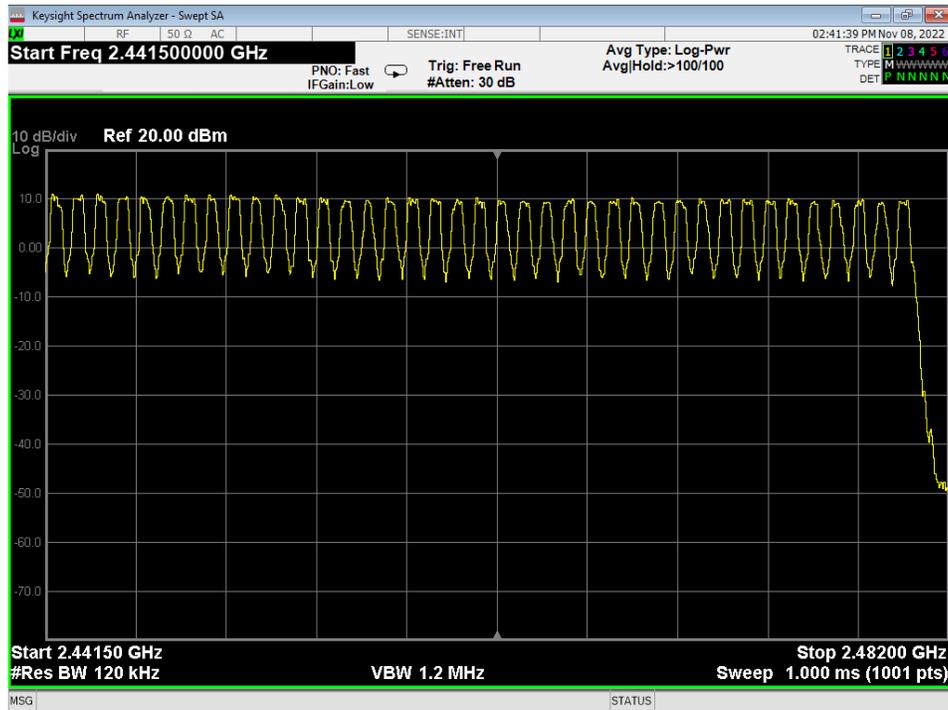
11 Dwell Time, 3.16S (reported for better resolution)



12 Dwell Time, 31.6S



13 Channel Count, 2400-2441.5M



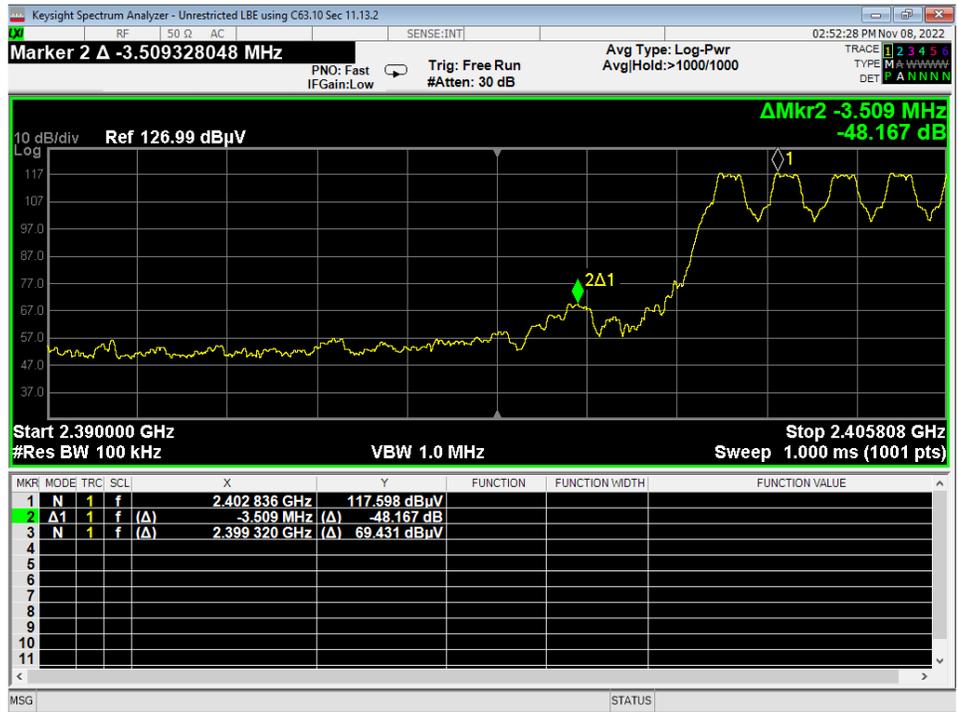
14 Channel Count, 2441.5-2482M



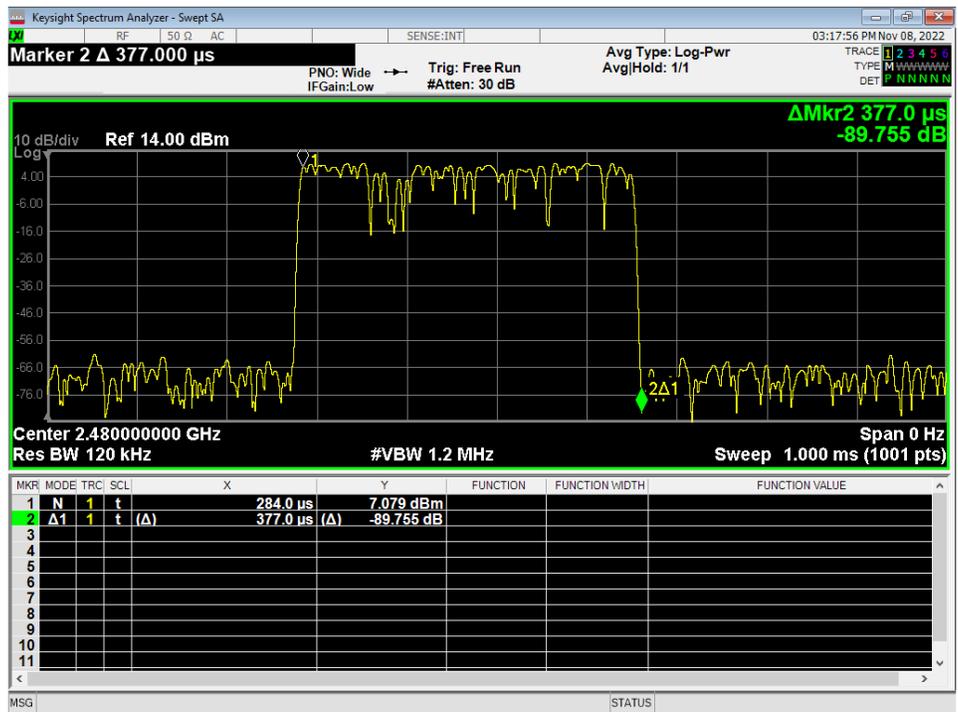
15 Frequency Separation



16 Higher Bandedge, Unrestricted, Hopping



17 Lower Bandedge, Unrestricted, Hopping



18 ON Time BTBR Hopping

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REPORT END

## FCC/ISED Test Report

**Prepared for:** **Garmin International, Inc.**

**Address:** **1200 E. 151<sup>st</sup> Street**  
**Olathe, Kansas, 66062, USA**

**Product:** **A04452**

**Test Report No:** **R20220901-21-E1C**

**Approved by:**



**Fox Lane,**  
**EMC Test Engineer**

**DATE:** **December 6, 2022**

**Total Pages:** **65**

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Prepared for:	Garmin International, Inc.		

**REVISION PAGE**

Rev. No.	Date	Description
0	21 November 2022	Issued – FLane Reviewed by KVepuri/NJohnson Prepared by FLane, GLarsen
A	22 November 2022	Remove reference to GFSK - FL
B	2 December 2022	Corrected Antenna Gain values - FL
C	6 December 2022	Removed Antenna Gain values – FL



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## 1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section:

### FCC Part 15.247

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15
- (2) ISED RSS-Gen, Issue 5
- (3) ISED RSS-247, Issue 2

APPLIED STANDARDS AND REGULATIONS		
Standard Section	Test Type	Result
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(b)(3) RSS-247 Issue 2 Section 5.4(d)	Peak output power	Pass
FCC Part 15.247(a)(2) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 5, Section 7.3	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 5, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(e) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 5.5	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass



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## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

#### Summary and Operating Condition:

<b>EUT</b>	A04452
<b>IC</b>	1792A-04452
<b>FCC ID</b>	IPH-04452
<b>EUT Received</b>	3 October 2022
<b>EUT Tested</b>	3 October 2022- 7 November 2022
<b>Serial No.</b>	3426283485 (Radiated Measurements) 3426283465 (Conducted Measurements)
<b>Operating Band</b>	2400 – 2483.5 MHz
<b>Device Type</b>	<input checked="" type="checkbox"/> GMSK <input type="checkbox"/> GFSK <input type="checkbox"/> BT BR <input type="checkbox"/> BT EDR 2MB <input type="checkbox"/> BT EDR 3MB <input type="checkbox"/> 802.11x
<b>Power Supply / Voltage</b>	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: AQ27A-59CFA GPN: 362-00118-00 (Representative Power Supply)

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

### 2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

GMSK 1MB Transmissions:

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

GMSK 2MB Transmissions:

Channel	Frequency
Low	2404 MHz
Mid	2440 MHz
High	2478 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

### 2.3 DESCRIPTION OF SUPPORT UNITS

None

## 3.0 LABORATORY AND GENERAL TEST DESCRIPTION

### 3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)  
 4740 Discovery Drive  
 Lincoln, NE 68521  
 A2LA Certificate Number: 1953.01  
 FCC Accredited Test Site Designation No: US1060  
 Industry Canada Test Site Registration No: 4294A  
 NCC CAB Identification No: US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of  $35 \pm 4\%$   
 Temperature of  $22 \pm 3^\circ$  Celsius



### 3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Review/Testing and Report
2	Blake Winter	Test Engineer	Testing
3	Grace Larsen	Test Engineer	Testing and Report
4	Ethan Schmidt	Test Technician	Testing

**Notes:** All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.



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### 3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
ETS EMCO Red Horn Antenna	3115	00218655	July 21, 2022	July 21, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preampfier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Rohde & Schwarz Preampfier*	TS-PR18	3545700803	August 22, 2022	August 22, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber***	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preampfier to antenna)*	MFR-57500	90-195-040	August 22, 2022	August 22, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

\*Internal Characterization

\*\*2 Year Cal Cycle

\*\*\*3 Year Cal Cycle

**Notes:**

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

### 3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMENTS

Measurement type presented in this report (Please see the checked box below):

#### Conducted

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

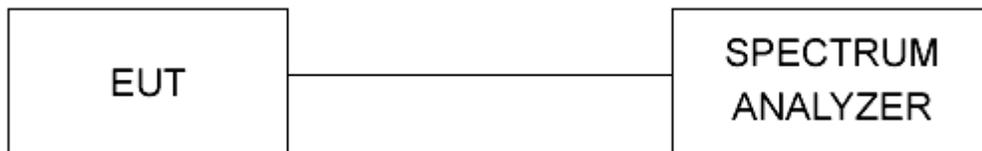


Figure 1 - Bandwidth Measurements Test Setup

#### Radiated

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

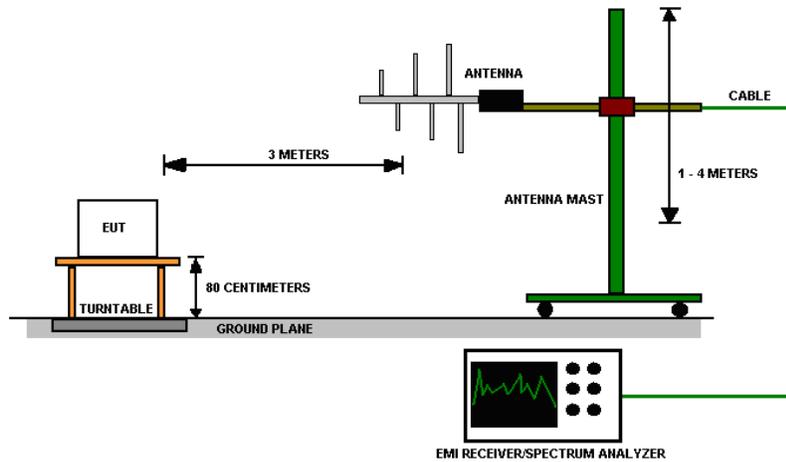


Figure 2 - Radiated Emissions Test Setup



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#### 4.0 RESULTS

DTS Radio Measurements							
CHANNEL	Transmitter	Occupied Bandwidth (kHz)	6 dB Bandwidth (kHz)	AVERAGE OUTPUT POWER (dBm)	AVERAGE OUTPUT POWER (mW)	PSD (dBm)	RESULT
Low	GMSK 1Mb	1365.60	1385.70	-2.680	0.540	-18.703	PASS
Mid	GMSK 1Mb	1358.80	1374.50	1.540	1.426	-14.373	PASS
High	GMSK 1Mb	1347.20	1329.60	-1.950	0.638	-18.537	PASS
Low	GMSK 2Mb	2597.70	2541.90	1.210	1.321	-14.738	PASS
Mid	GMSK 2Mb	2636.90	2575.00	1.520	1.419	-15.313	PASS
High	GMSK 2Mb	2618.90	2551.60	-2.430	0.571	-19.619	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit = 500 kHz				Peak Output Power Limit = 30 dBm; PSD Limit = 8 dBm			
Unrestricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamental (dBuV)	Delta (dB)	Min Delta (dB)	Result
Low	GMSK 1Mb	2400.00	64.309	104.175	39.866	30.00	PASS
Low	GMSK 2Mb	2400.00	65.392	106.107	40.715	30.00	PASS
High	GMSK 1Mb	2483.50	51.553	103.856	52.303	30.00	PASS
High	GMSK 2Mb	2483.50	58.594	101.353	42.759	30.00	PASS
Peak Restricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	GMSK 1Mb	2390.00	52.788	Peak	73.98	21.19	PASS
Low	GMSK 2Mb	2390.00	51.778	Peak	73.98	22.20	PASS
High	GMSK 1Mb	2483.50	57.126	Peak	73.98	16.85	PASS
High	GMSK 2Mb	2483.50	61.812	Peak	73.98	12.17	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							



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Average Restricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	GMSK 1Mb	2390.00	41.488	Average	53.98	12.49	PASS
Low	GMSK 2Mb	2390.00	43.839	Average	53.98	10.14	PASS
High	GMSK 1Mb	2483.50	48.248	Average	53.98	5.73	PASS
<b>High</b>	<b>GMSK 2Mb</b>	<b>2483.50</b>	<b>53.364</b>	<b>Average</b>	<b>53.98</b>	<b>0.62</b>	<b>PASS</b>

\*Limit shown is the average limit taken from FCC Part 15.209



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#### 4.1 OUTPUT POWER

**Test Method:** All measurements were performed using the section 11.9.2.2.2 from ANSI C63.10.

**Limits of power measurements:**

**For FCC Part 15.247 Device:**

The maximum allowed output power is 30 dBm.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the output power plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. Tabulated data is listed in section 4.0.



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## 4.2 BANDWIDTH

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of bandwidth measurements:**

**For FCC Part 15.247 Device:**

The 99% occupied bandwidth is for informational purpose only. The 6dB bandwidth of the signal must be greater than 500 kHz.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the bandwidth plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. Tabulated data is listed in section 4.0.



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### 4.3 DUTY CYCLE

**Test Method:**

All Modulations/transmitters shown have a duty cycle of >98%.

#### 4.4 RADIATED EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.5, 6.6

**Limits for radiated emissions measurements:**

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ( $\mu\text{V/m}$ )	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

**NOTE:**

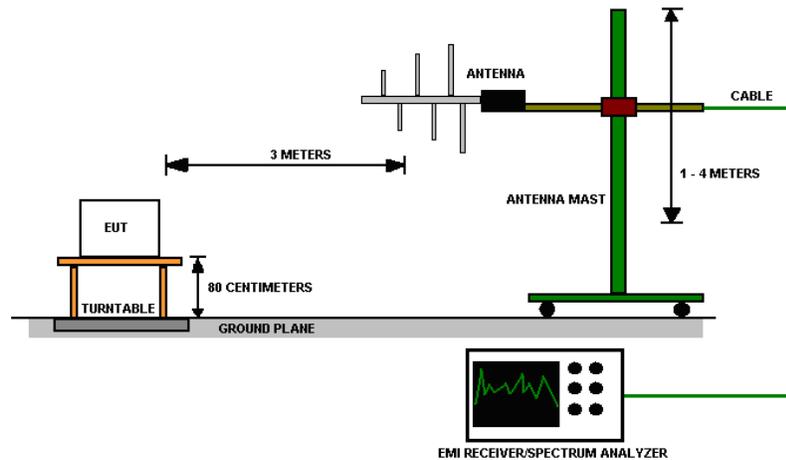
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) =  $20 * \log * \text{Emission level } (\mu\text{V/m})$ .
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.



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**Test procedures:**

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

**Test setup:**

**Figure 3 - Radiated Emissions Test Setup**
**NOTE:**

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

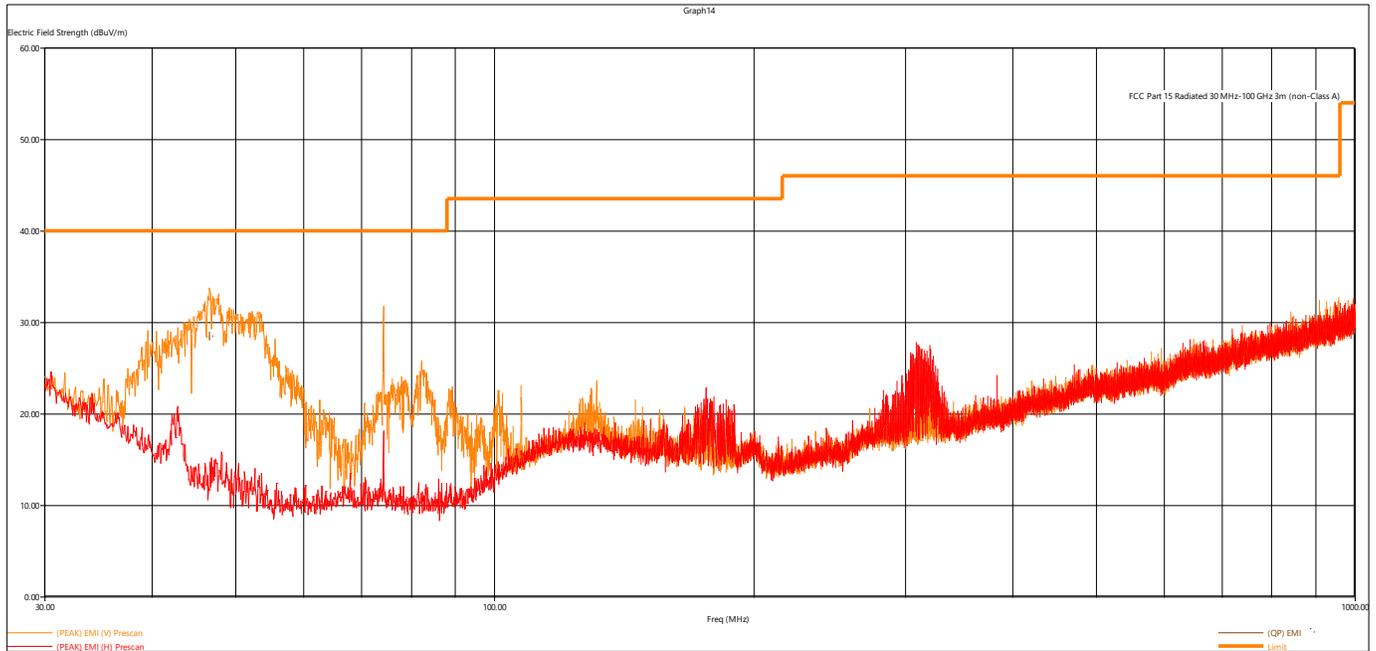
**Deviations from test standard:**

No deviation.

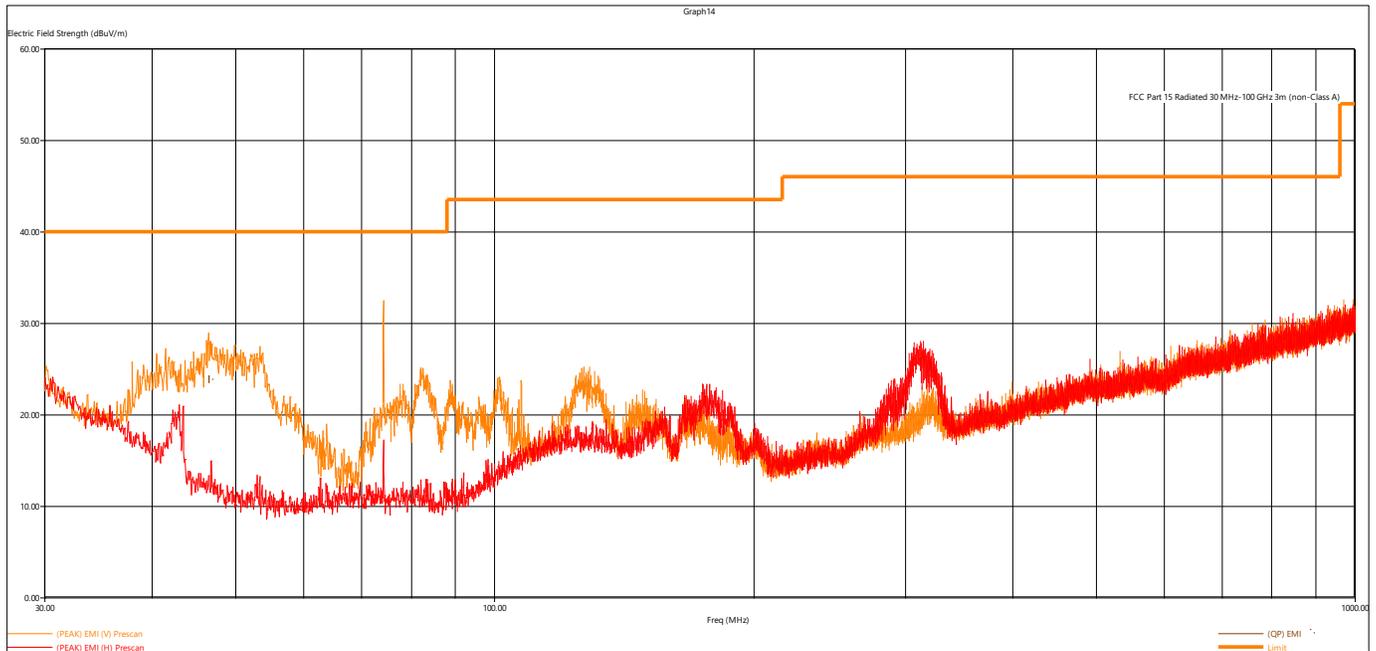
**EUT operating conditions**

Details can be found in section 2.1 of this report.

**Test results:**



**Figure 4 - Radiated Emissions Plot, Receive**



**Figure 5 - Radiated Emissions Plot, GSK 1MB**

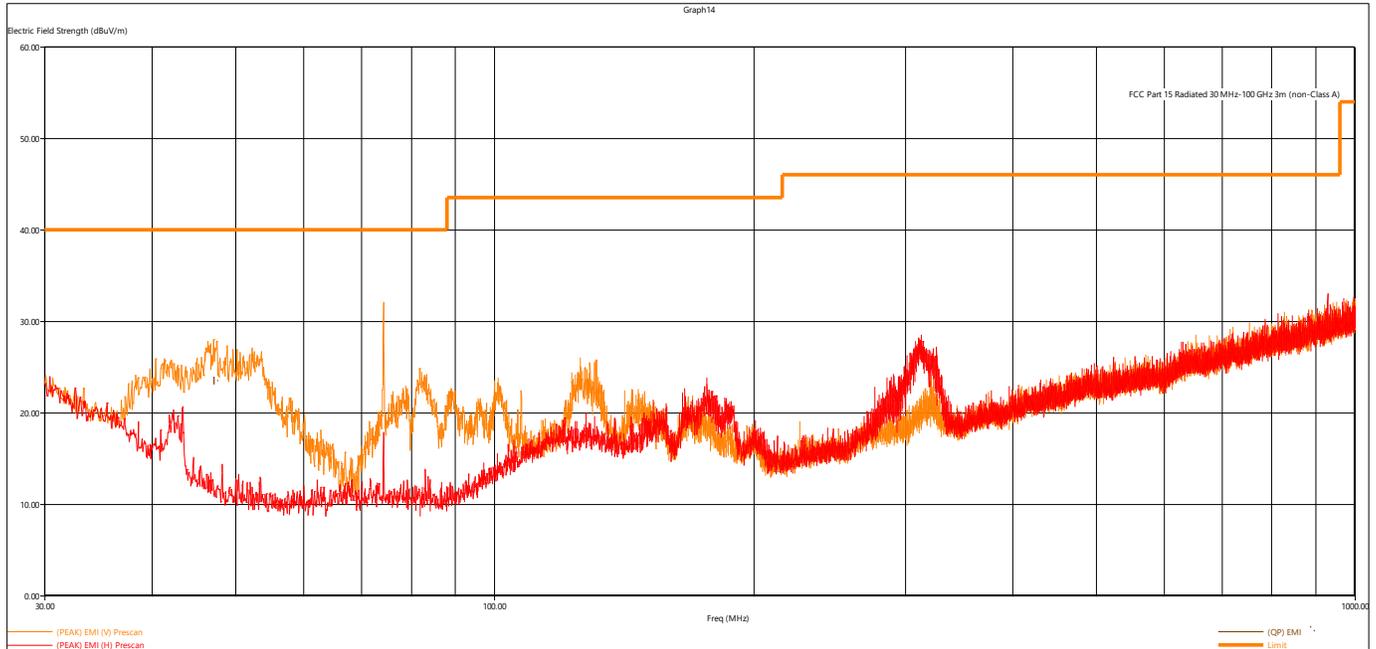


Figure 6 - Radiated Emissions Plot, GMSK 2MB

**REMARKS:**

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value - Emission level

Quasi-Peak Measurements, GMSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.			
46.474560	23.85	40.00	16.15	106.00	327.00	V	Low	GMSK 1MB
46.955520	23.47	40.00	16.53	107.00	234.00	V	Low	GMSK 2MB
46.431840	28.41	40.00	11.59	106.00	235.00	V	RX	

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above. All other measurements were found to be at least 6 dB below the limit.

Peak Measurements, GMSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.			
2402.224000	96.30	NA	NA	119.00	7.00	V	Low	GMSK 1MB
2440.176000	100.31	NA	NA	185.00	359.00	V	Mid	GMSK 1MB
2479.698000	97.65	NA	NA	174.00	4.00	V	High	GMSK 1MB
2404.496000	99.56	NA	NA	164.00	7.00	V	Low	GMSK 2MB
2439.460000	100.32	NA	NA	183.00	359.00	V	Mid	GMSK 2MB



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2477.534000	98.06	NA	NA	180.00	3.00	V	High	GMSK 2MB
7206.458000	54.12	73.98	19.86	147.00	167.00	V	Low	GMSK 1MB
7319.674000	54.51	73.98	19.47	123.00	170.00	V	Mid	GMSK 1MB
7441.038000	52.22	73.98	21.76	167.00	166.00	V	High	GMSK 1MB
7212.844000	53.26	73.98	20.72	138.00	169.00	V	Low	GMSK 2MB
7318.482000	55.28	73.98	18.70	199.00	167.00	V	Mid	GMSK 2MB
7432.264000	52.63	73.98	21.35	556.00	330.00	H	High	GMSK 2MB
9919.194000	54.87	73.98	19.11	312.00	131.00	V	High	GMSK 1MB
9914.924000	51.78	73.98	22.20	153.00	137.00	V	High	GMSK 2MB

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above.  
All other measurements were found to be at least 6 dB below the limit.

Average Measurements, GMSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.			
2402.224000	93.79	NA	NA	119.00	7.00	V	Low	GMSK 1MB
2440.176000	98.12	NA	NA	185.00	359.00	V	Mid	GMSK 1MB
2479.698000	94.26	NA	NA	174.00	4.00	V	High	GMSK 1MB
2404.496000	93.33	NA	NA	164.00	7.00	V	Low	GMSK 2MB
2439.460000	93.67	NA	NA	183.00	359.00	V	Mid	GMSK 2MB
2477.534000	92.02	NA	NA	180.00	3.00	V	High	GMSK 2MB
7206.458000	44.51	53.98	9.47	147.00	167.00	V	Low	GMSK 1MB
7319.674000	47.40	53.98	6.58	123.00	170.00	V	Mid	GMSK 1MB
7441.038000	41.31	53.98	12.67	167.00	166.00	V	High	GMSK 1MB
7212.844000	43.38	53.98	10.60	138.00	169.00	V	Low	GMSK 2MB
7318.482000	44.63	53.98	9.35	199.00	167.00	V	Mid	GMSK 2MB
7432.264000	40.85	53.98	13.13	556.00	330.00	H	High	GMSK 2MB
9919.194000	45.04	53.98	8.94	312.00	131.00	V	High	GMSK 1MB
9914.924000	39.01	53.98	14.97	153.00	137.00	V	High	GMSK 2MB

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the table above.  
All other measurements were found to be at least 6 dB below the limit.



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#### 4.5 CONDUCTED SPURIOUS EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.7

**Limits of spurious emissions:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

**Test procedures:**

The highest emissions level was measured and recorded. All spurious measurements were evaluated to 30dB below the fundamental. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

None.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

Note that the limit shown on the plots does not apply. It is a line for reference

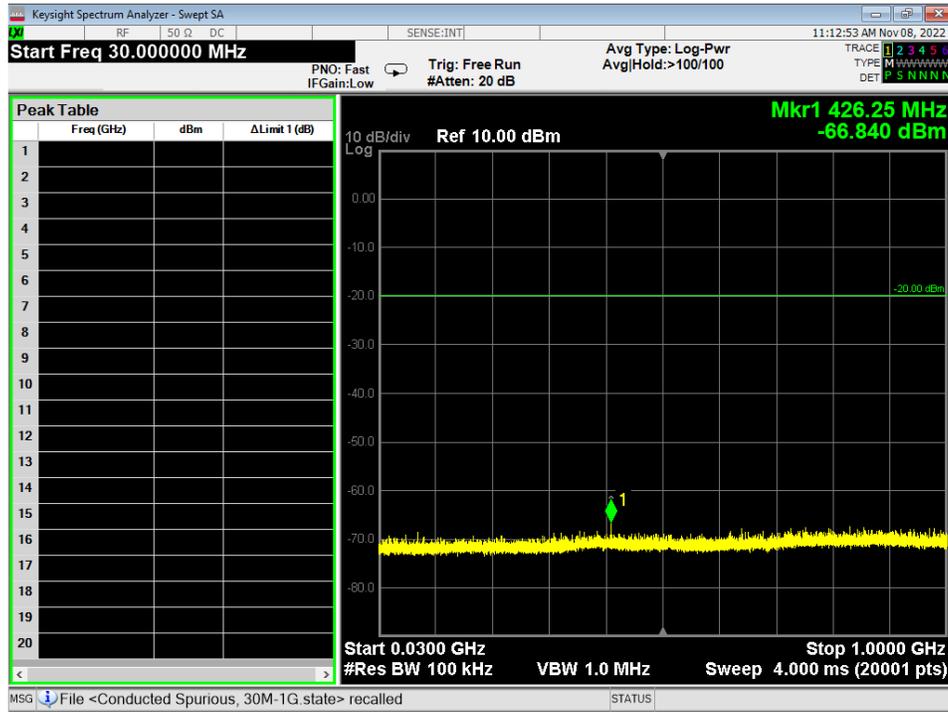


Figure 7 - Radiated Emissions Plot, GMSK 1MB, 30MHz – 1GHz, Mid

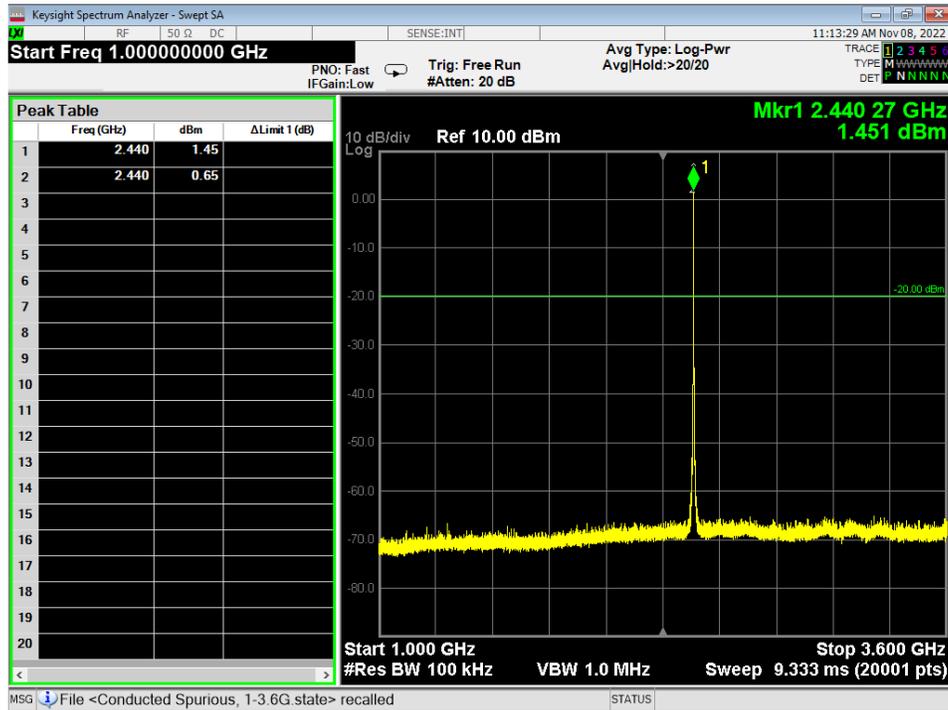


Figure 8 - Radiated Emissions Plot, GMSK 1MB, 1GHz – 3.6GHz, Mid

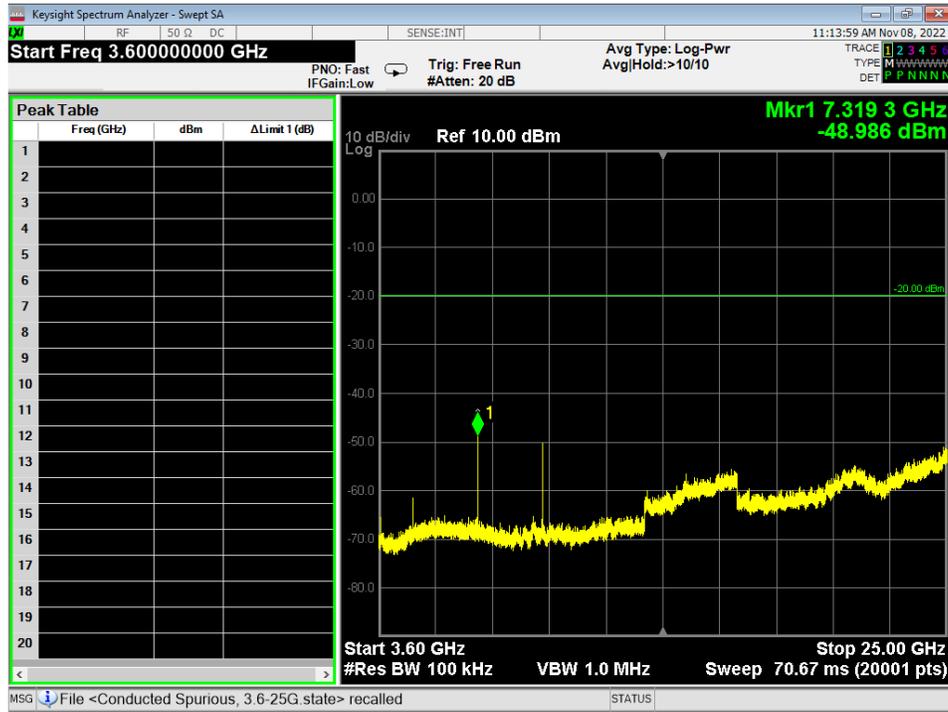


Figure 9 - Radiated Emissions Plot, GMSK 1MB, 3.6GHz – 25GHz, Mid

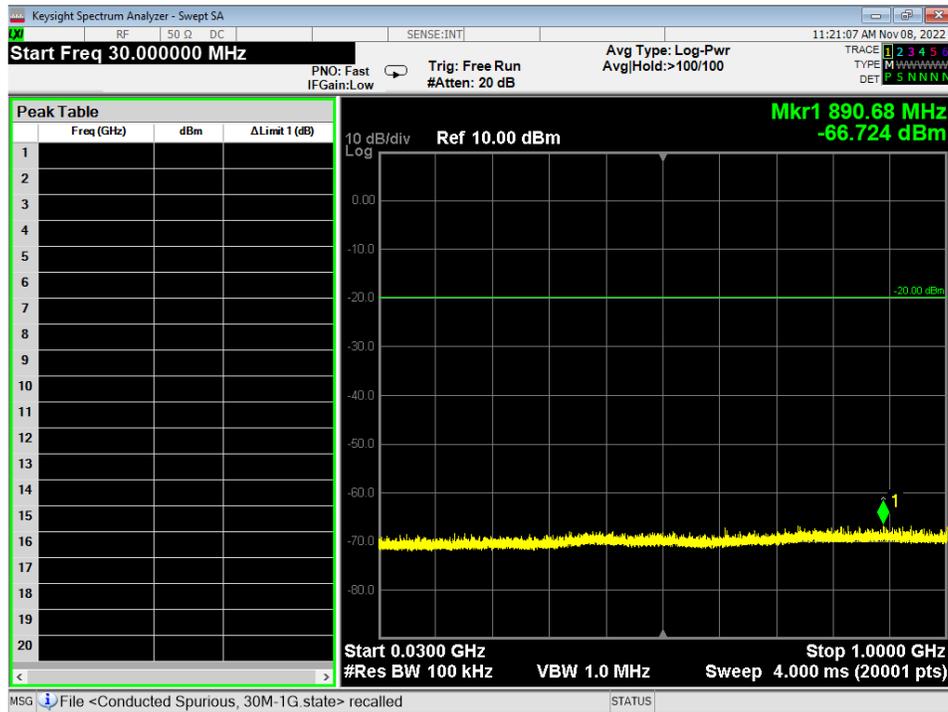


Figure 10 - Radiated Emissions Plot, GMSK 2MB, 30MHz – 1GHz, Mid

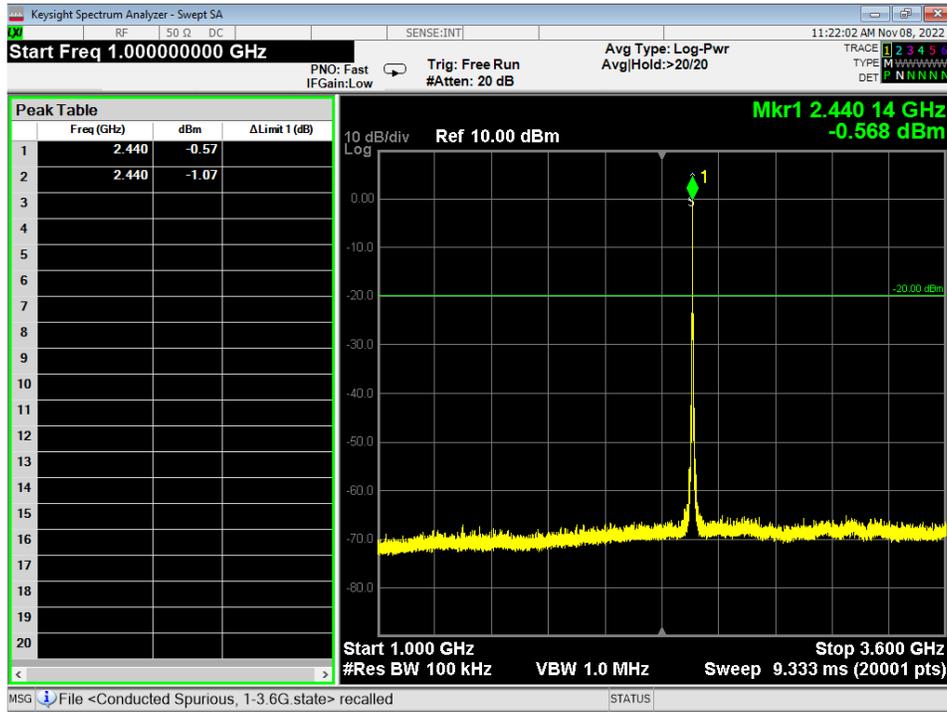


Figure 11 - Radiated Emissions Plot, GMSK 2MB, 1GHz – 3.6GHz, Mid

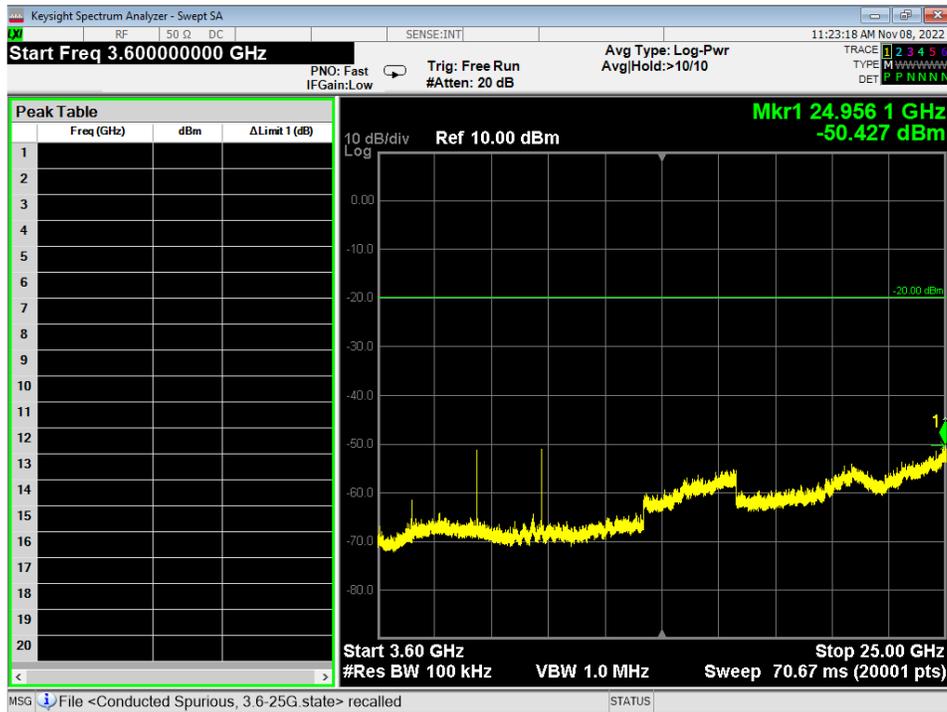


Figure 12 - Radiated Emissions Plot, GMSK 2MB, 3.6GHz – 25GHz, Mid



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#### 4.6 BAND EDGES

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of band-edge measurements:**

**For FCC Part 15.247 Device:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

**Test procedures:**

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.



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**Test results:**

**Pass**

Comments:

1. All the band edge plots can be found in the Appendix C.
2. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209.
4. Tabulated data is listed in section 4.0.



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## 4.7 POWER SPECTRAL DENSITY

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of power measurements:**

**For FCC Part 15.247 Device:**

The maximum PSD allowed is 8 dBm.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

### Pass

**Comments:**

1. All the Power Spectral Density (PSD) plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. Tabulated data is listed in section 4.0.

## 4.8 CONDUCTED AC MAINS EMISSIONS

**Test Method:** ANSI C63.10-2013, Section(s) 6.2

**Limits for conducted emissions measurements:**

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dB $\mu$ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

**Notes:**

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

**Test Procedures:**

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

**Deviation from the test standard:**

No deviation

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

Test Results:



Figure 13 - Conducted Emissions Plot, Line, TX



Figure 14 - Conducted Emissions Plot, Neutral, TX

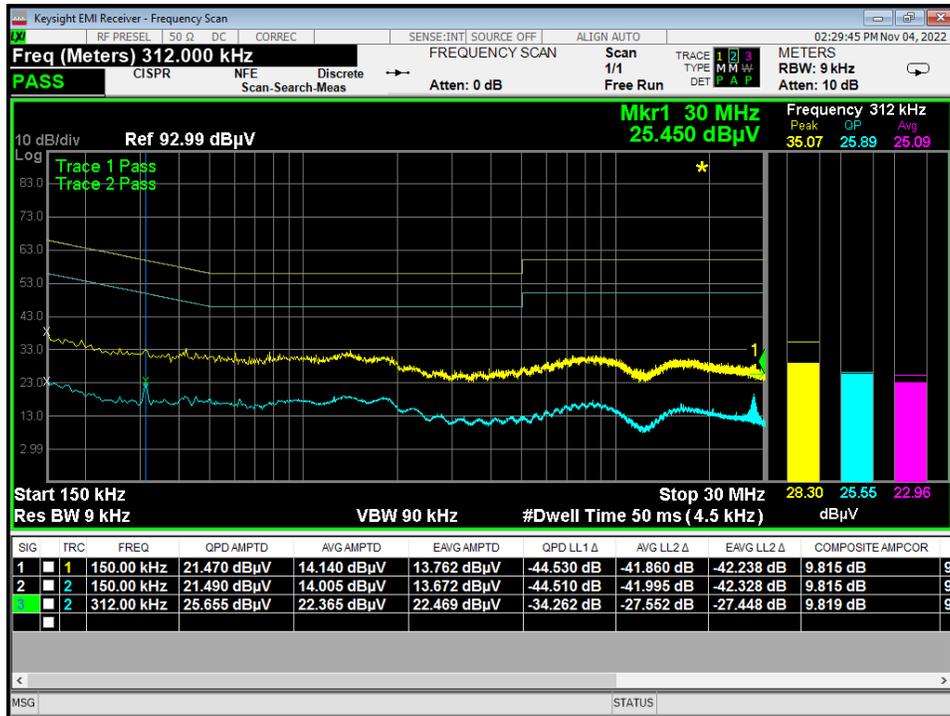


Figure 15 - Conducted Emissions Plot, Line, IDLE



Figure 16 - Conducted Emissions Plot, Neutral, IDLE



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**APPENDIX A: SAMPLE CALCULATION**

**Field Strength Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

- RA = Receiver Amplitude
- AF = Antenna Factor
- CF = Cable Attenuation Factor
- AG = Amplifier Gain
- AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB $\mu$ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB $\mu$ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by the taking the  $20 \cdot \log(T_{on}/100)$  where  $T_{on}$  is the maximum transmission time in any 100ms window.



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**EIRP Calculations**

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

$$EIRP (Watts) = [Field Strength (V/m) \times antenna distance (m)]^2 / 30$$

$$Power (watts) = 10^{[Power (dBm)/10]} / 1000$$

$$Voltage (dB\mu V) = Power (dBm) + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$Field Strength (V/m) = 10^{[Field Strength (dB\mu V/m) / 20]} / 10^6$$

$$Gain = 1 \text{ (numeric gain for isotropic radiator)}$$

Conversion from 3m field strength to EIRP (d=3):

$$EIRP = [FS(V/m) \times d^2]/30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS(dB\mu V/m) - 95.23$$

*10log( 10^9) is the conversion from micro to milli*



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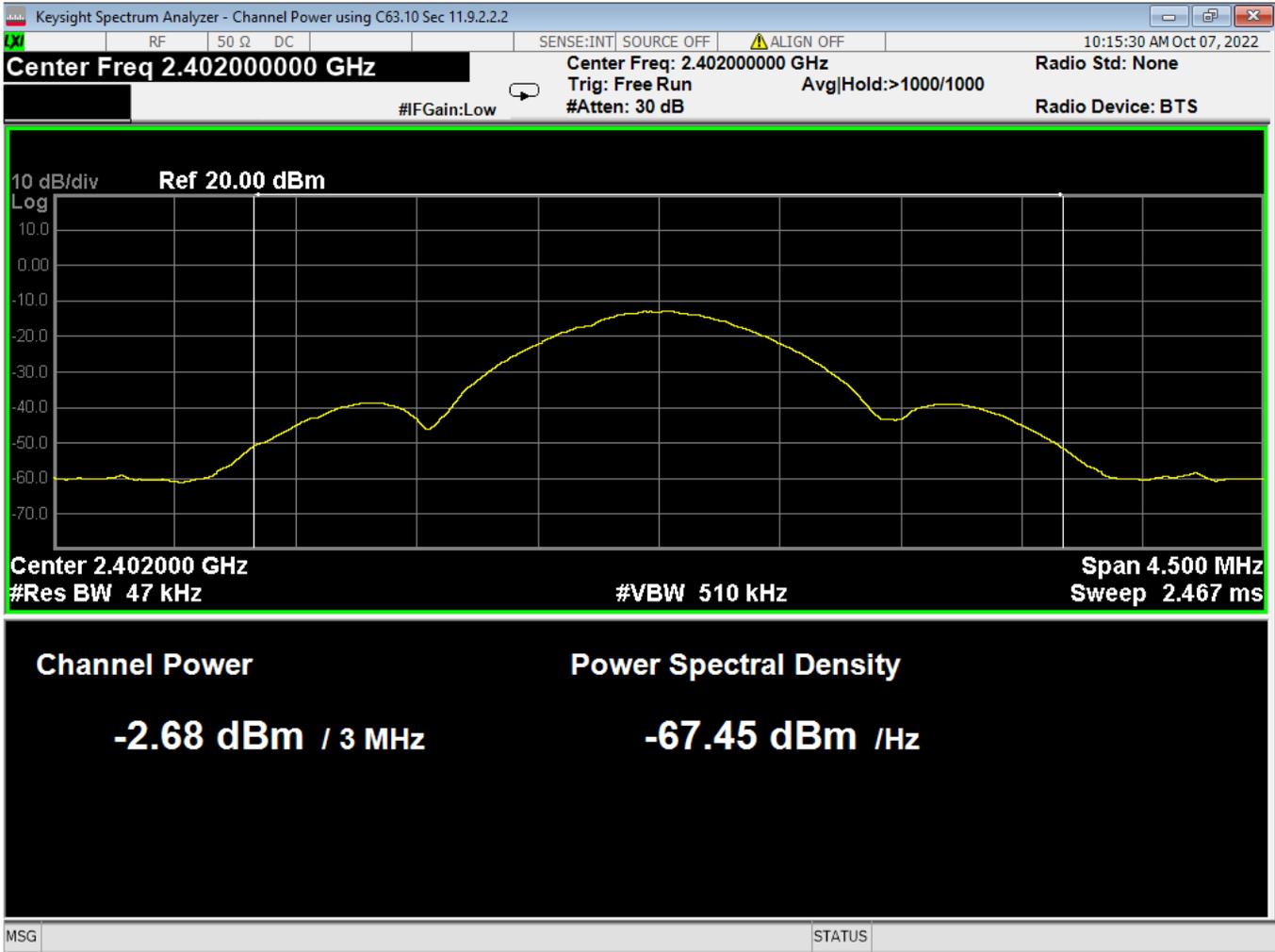
**APPENDIX B – MEASUREMENT UNCERTAINTY**

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

<b>Test</b>	<b>Frequency Range</b>	<b>Uncertainty Value (dB)</b>
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

Expanded uncertainty values are calculated to a confidence level of 95%.

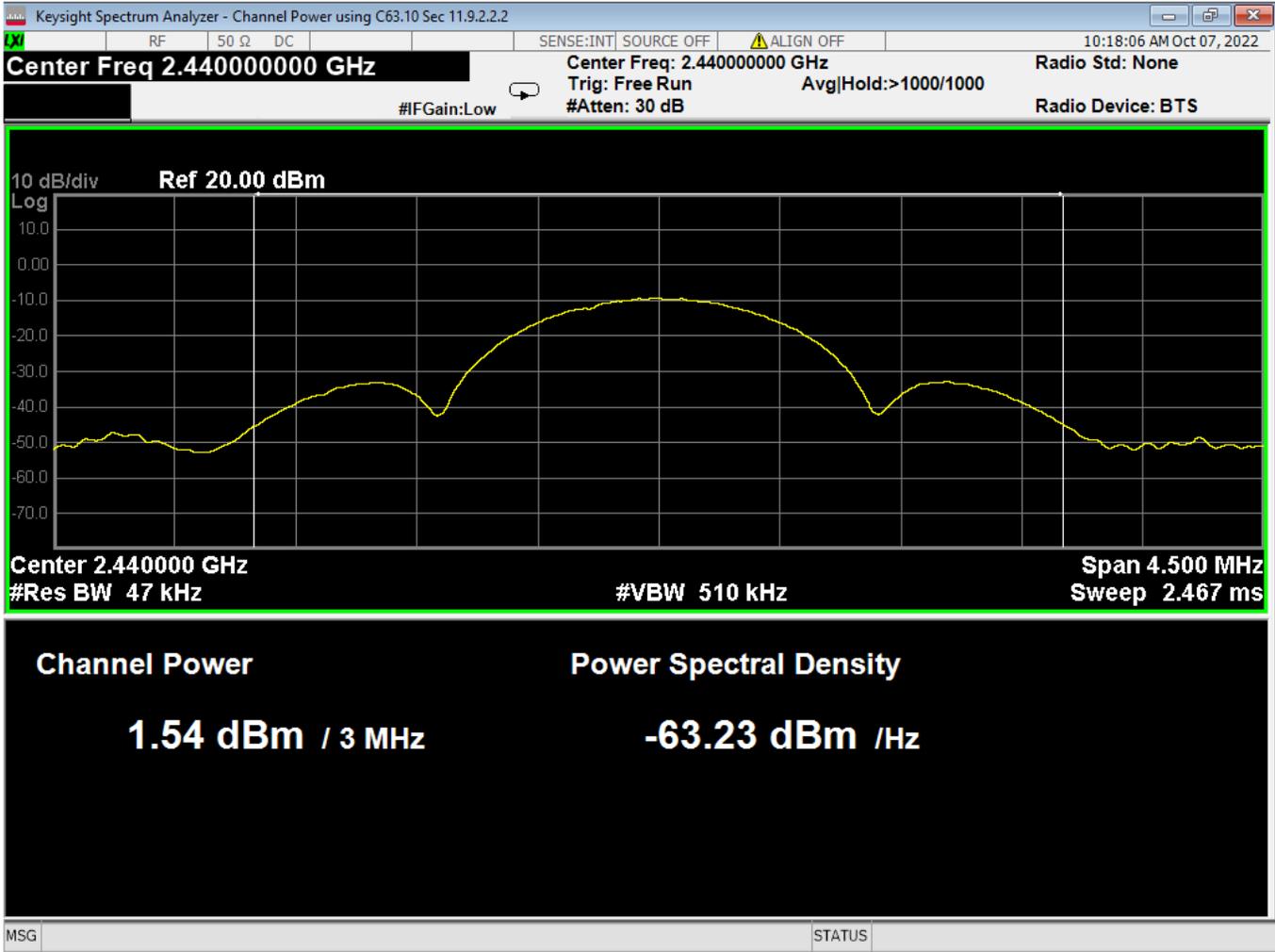
APPENDIX C – GRAPHS AND TABLES



14 Average Power, Low Channel, GMSK 1MB



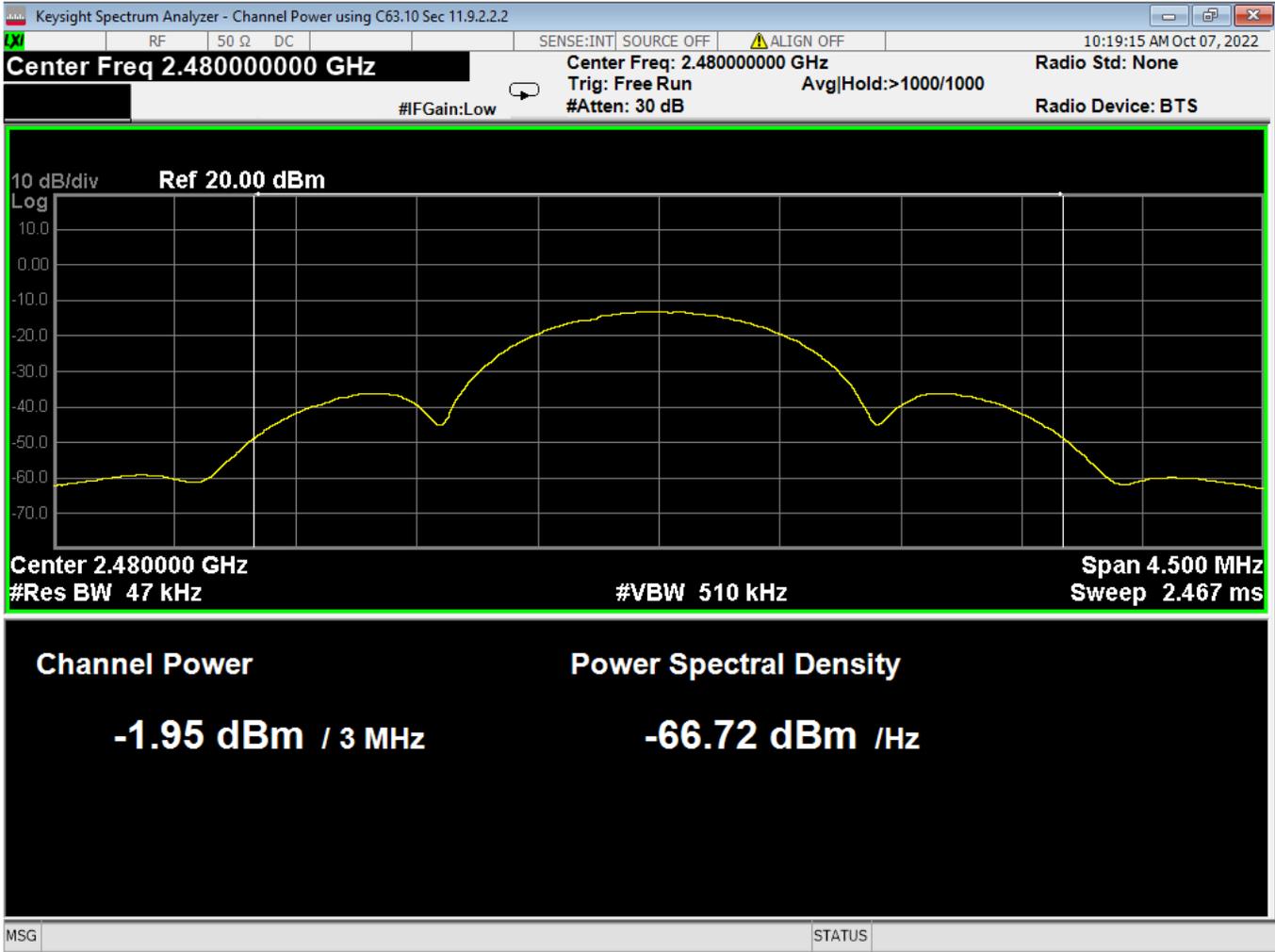
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15 Average Power, Mid Channel, GMSK 1MB



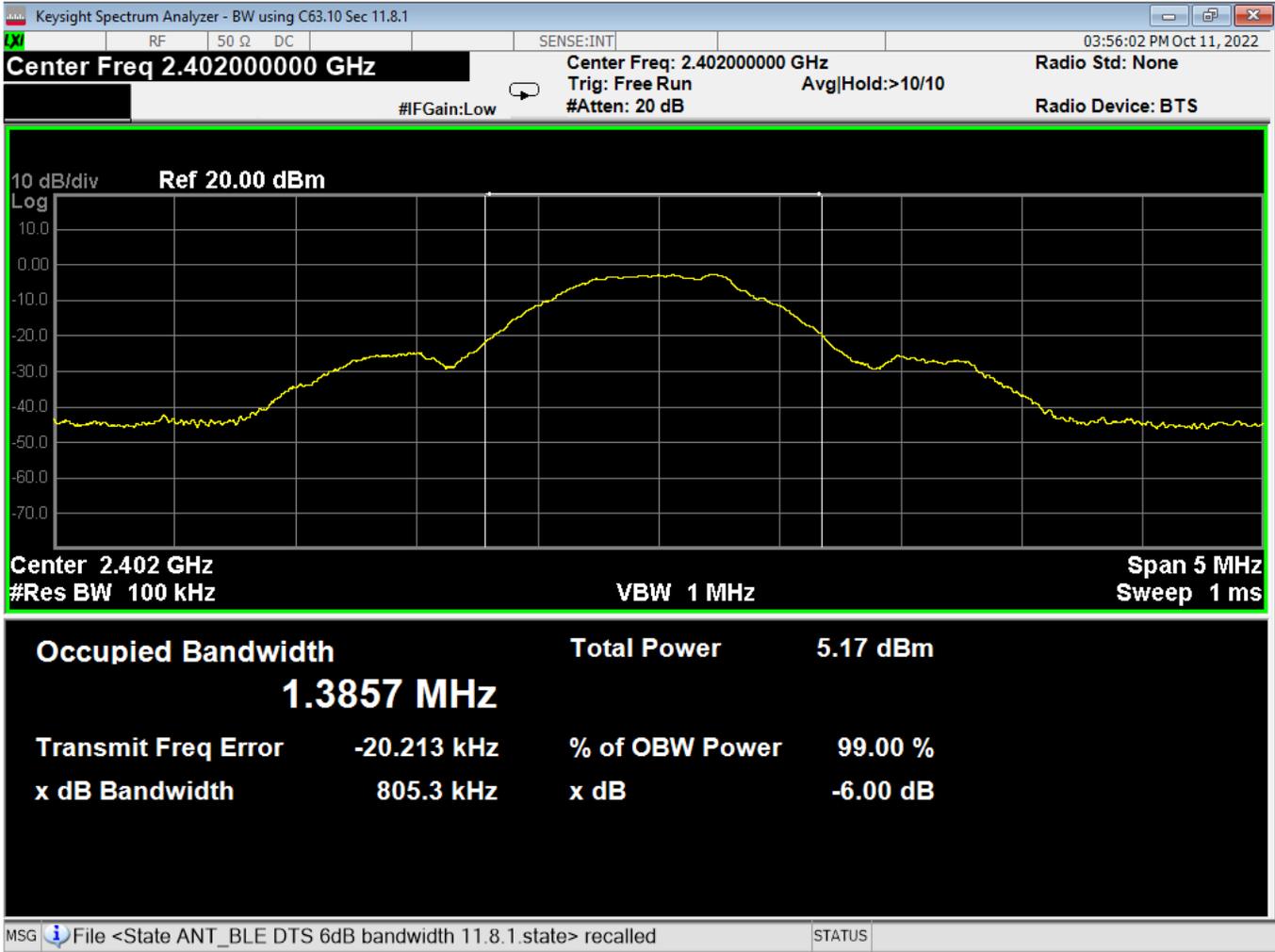
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16 Average Power, High Channel, GMSK 1MB



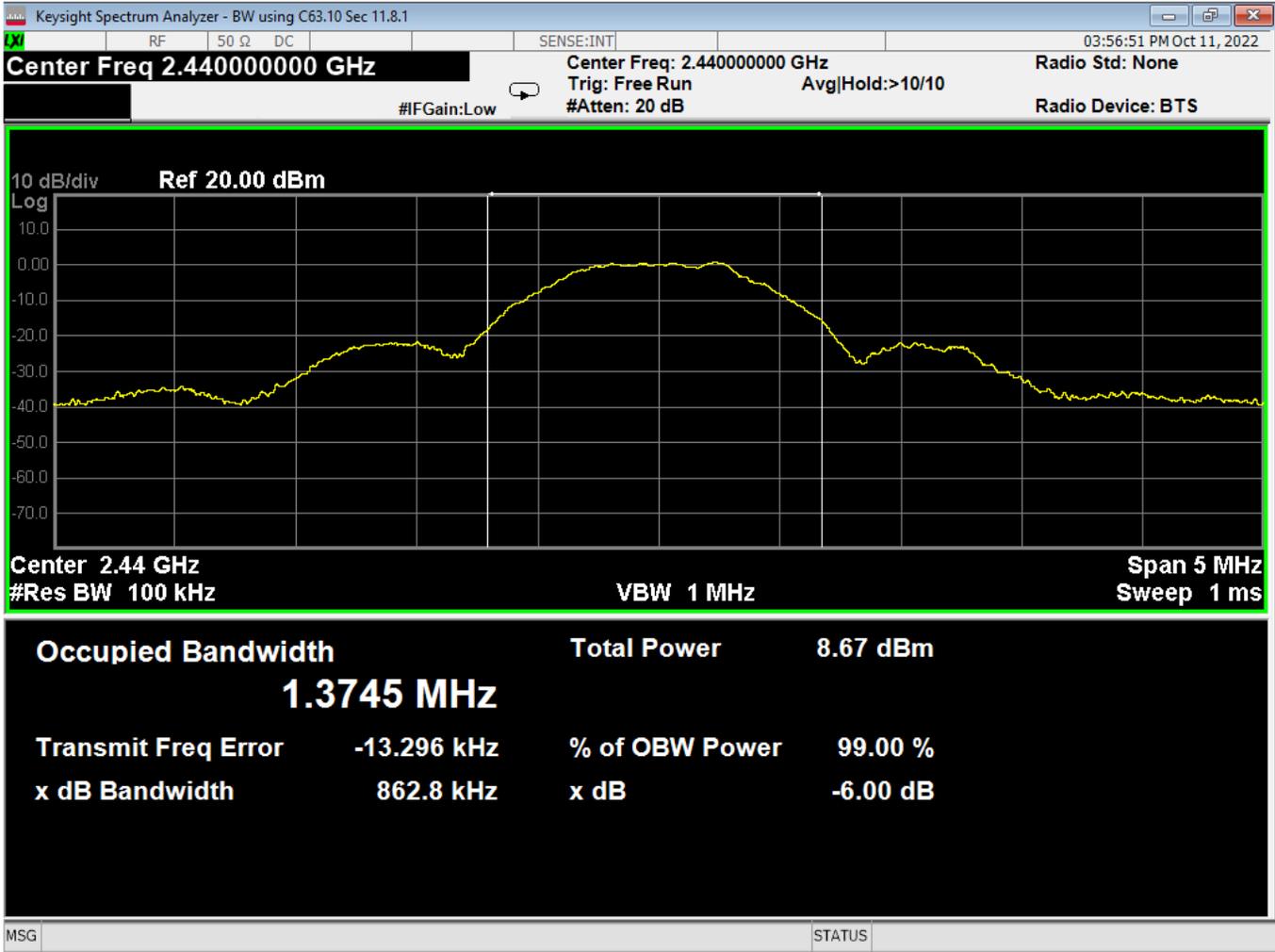
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17 6dB Bandwidth, Low Channel, GMSK 1MB



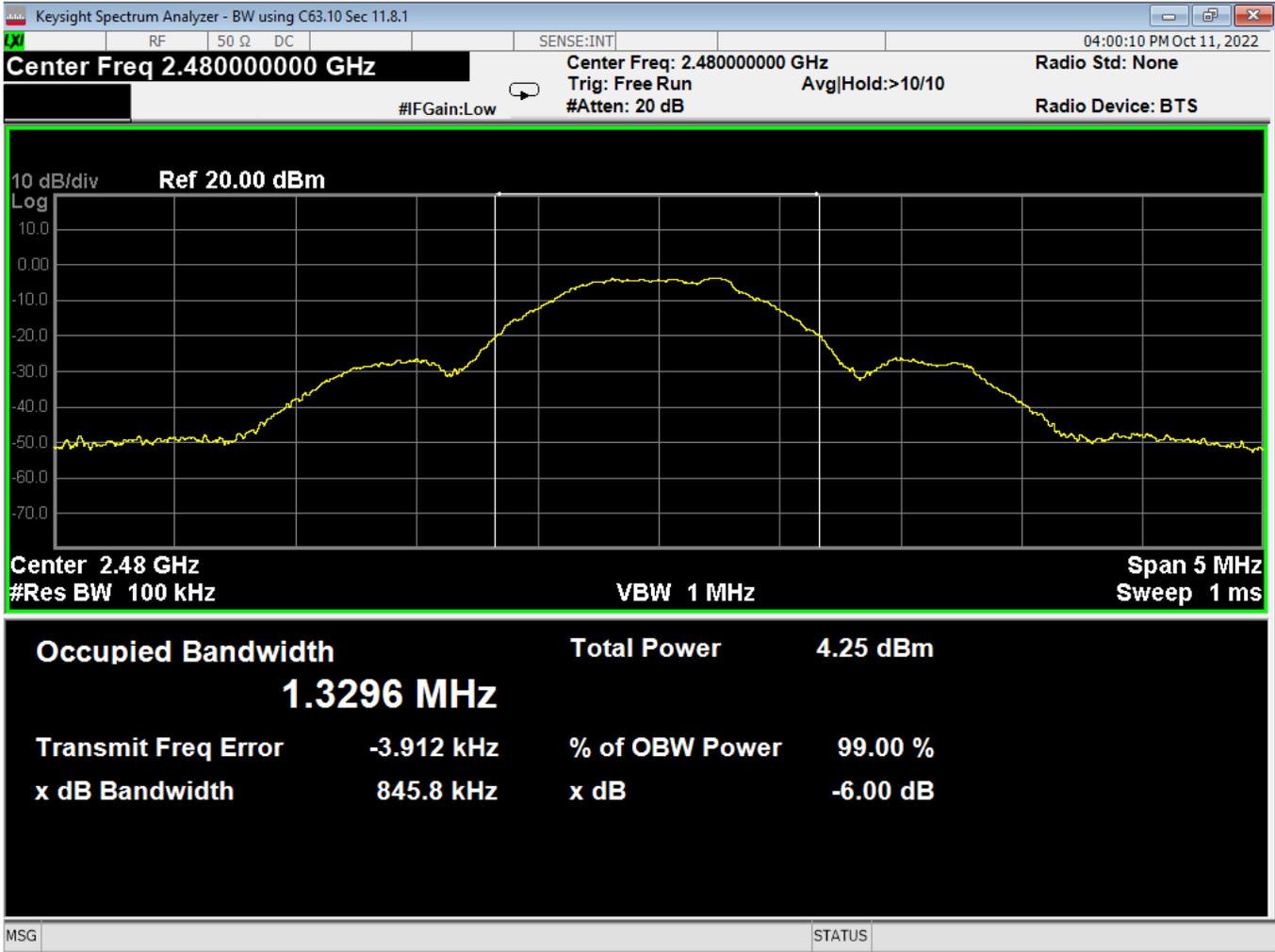
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18 dB Bandwidth, Mid Channel, GMSK 1MB



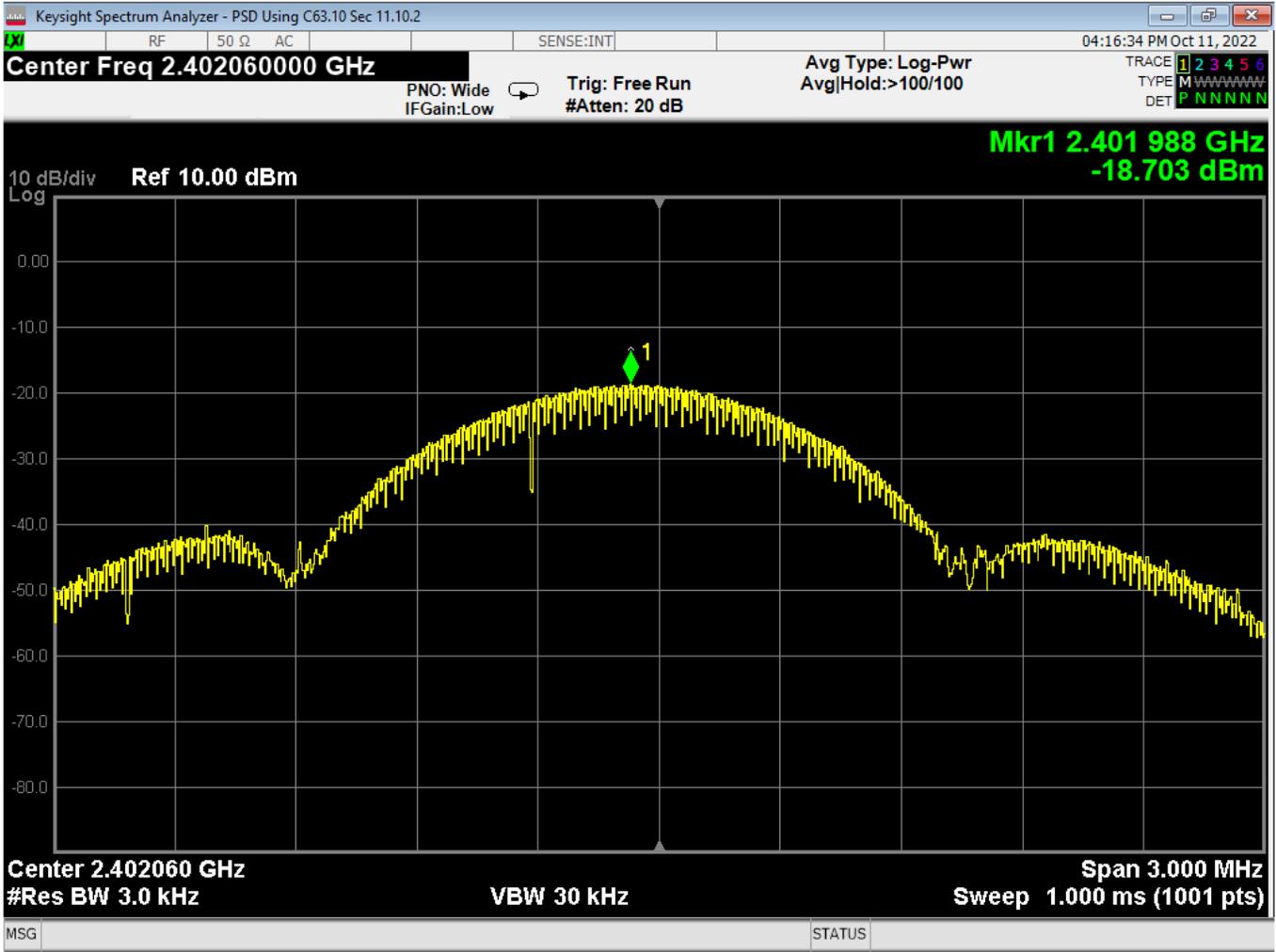
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19 6dB Bandwidth, High Channel, GMSK 1MB



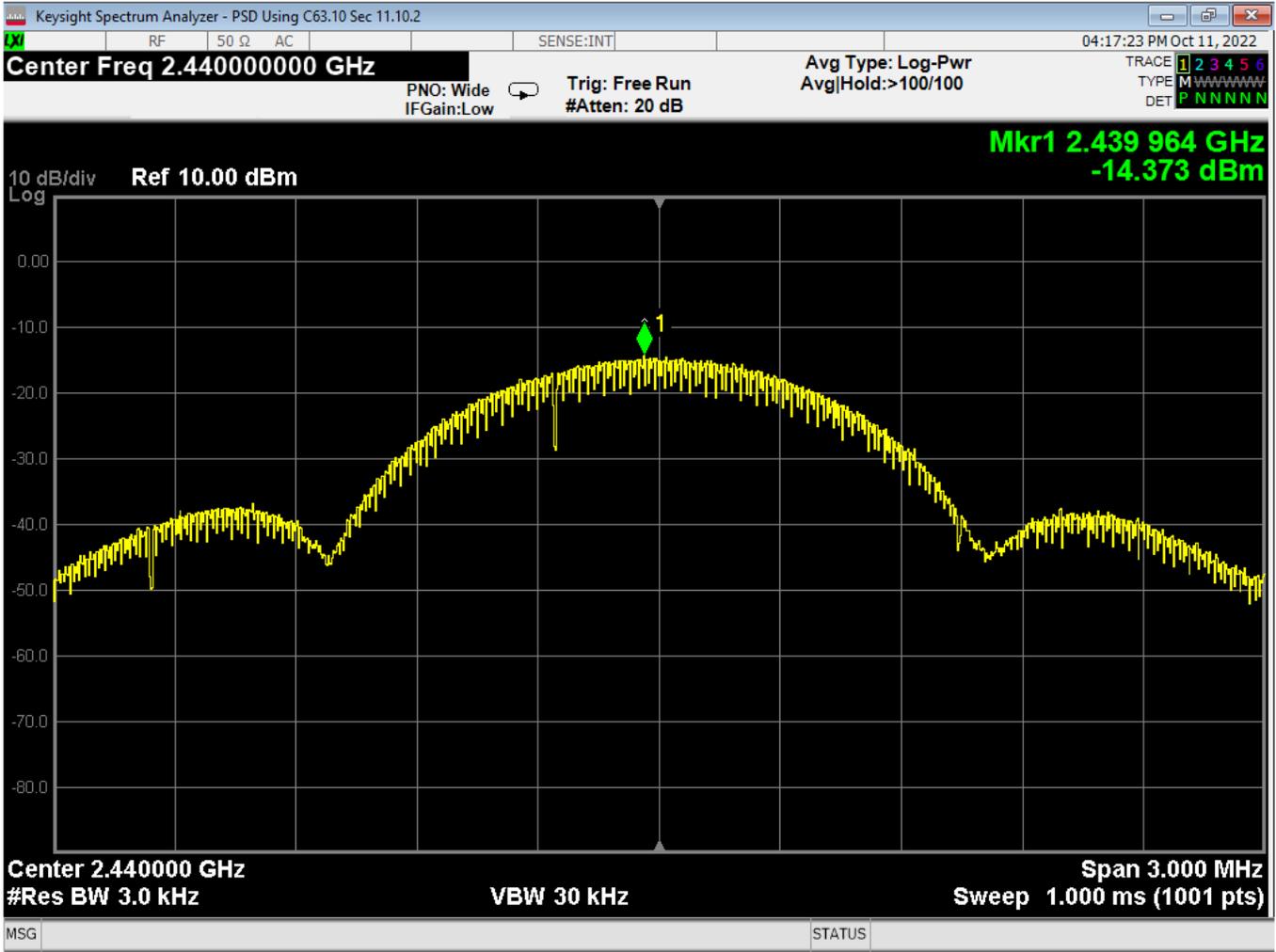
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Prepared for:	Garmin International, Inc.		



20 PSD, Low Channel, GMSK 1MB



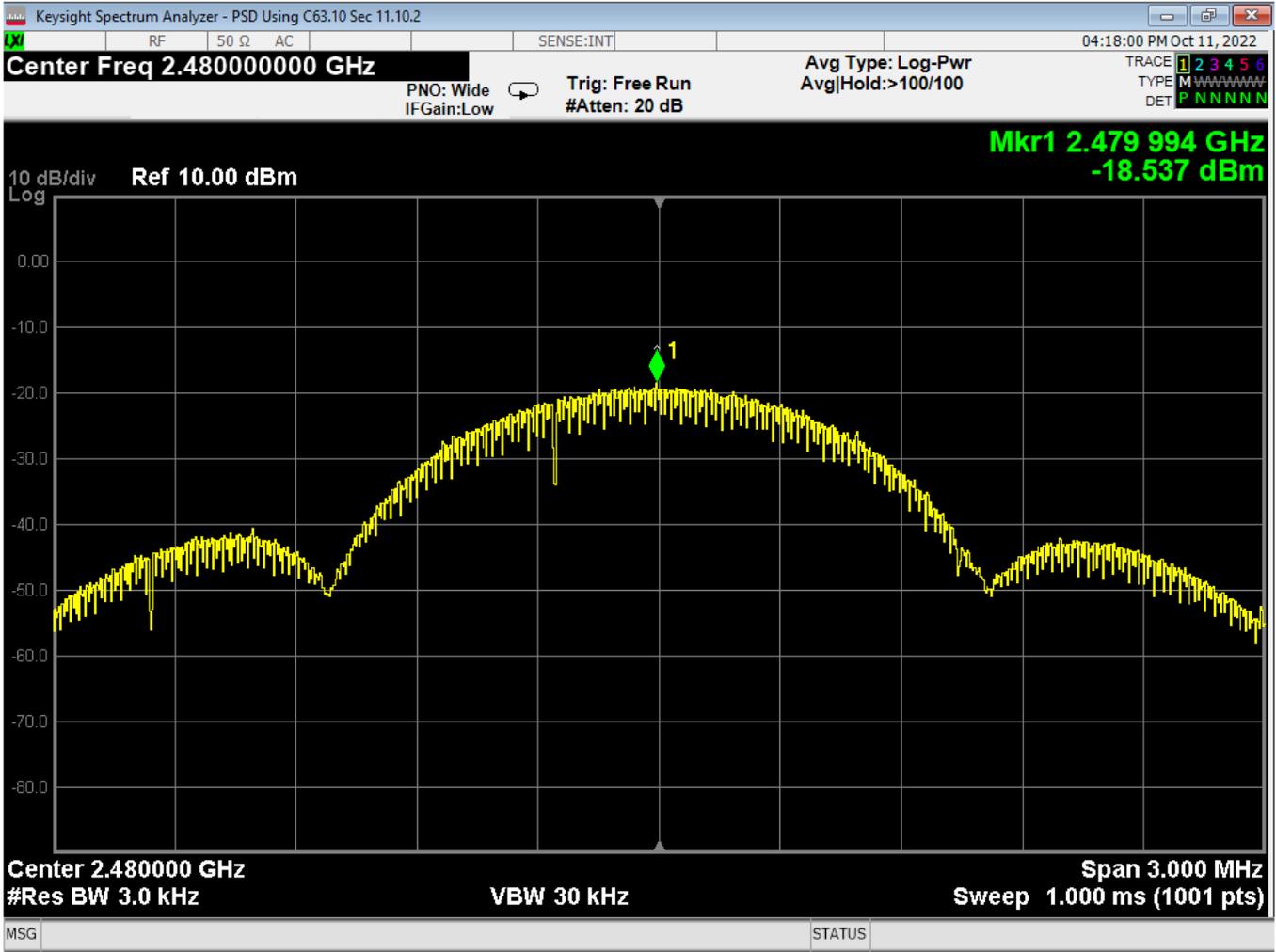
Report Number:	R20220901-21-E1C	Rev	B
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21 PSD, Mid Channel, GMSK 1MB



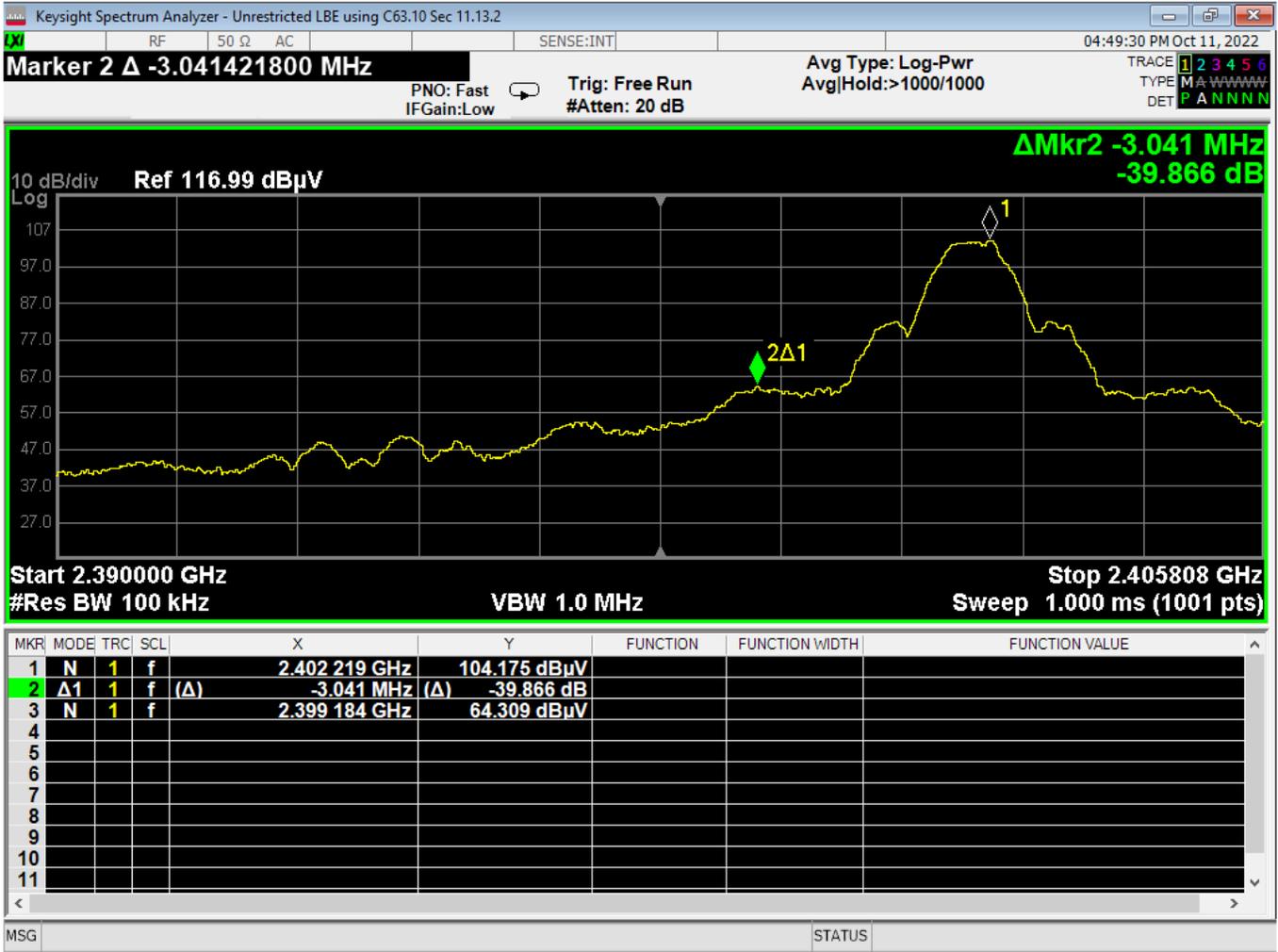
Report Number:	R20220901-21-E1C	Rev	B
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22 PSD, High Channel, GMSK 1MB



Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



23 LBE, unrestricted GMSK 1MB



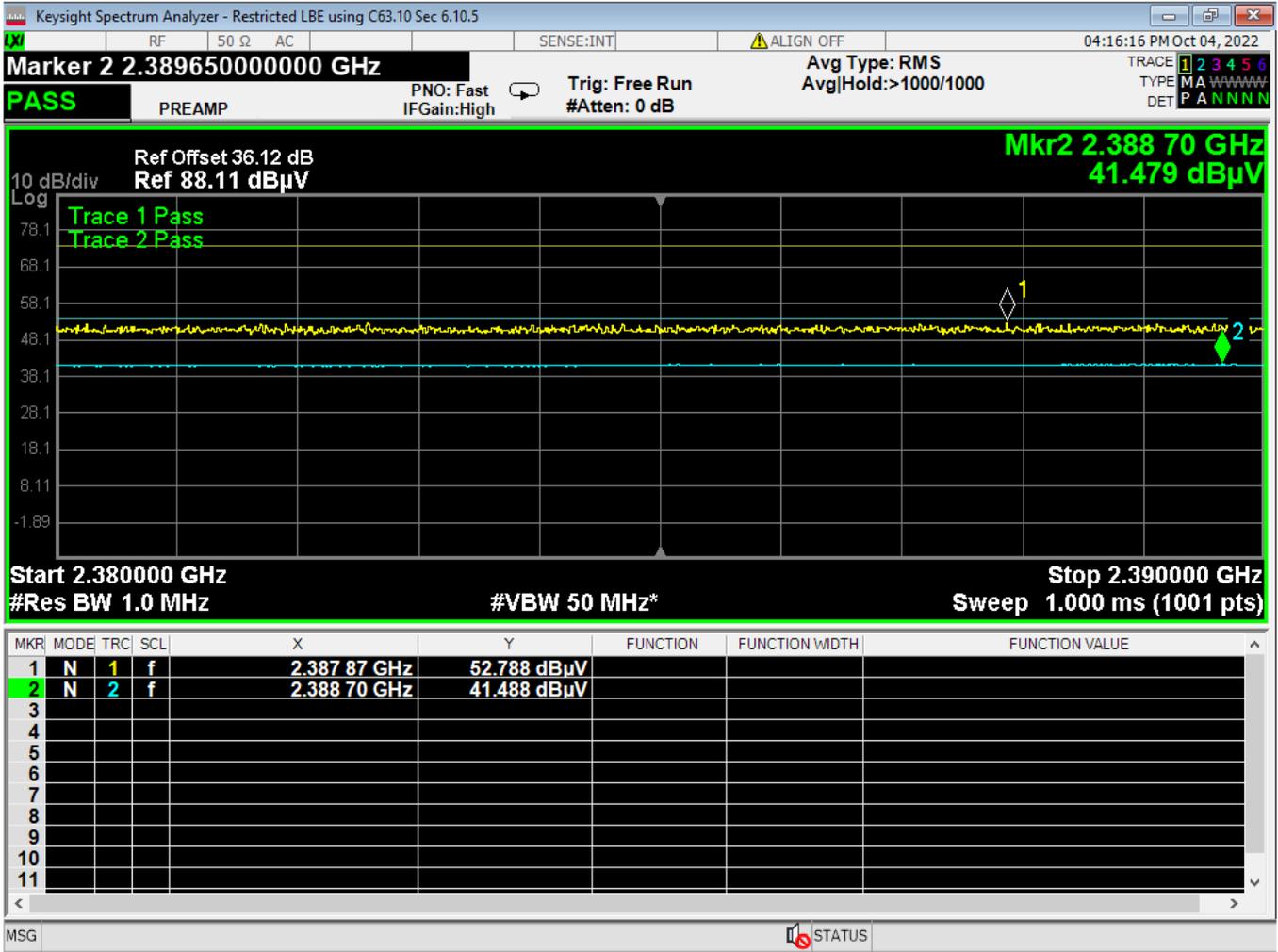
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



24 HBE, unrestricted GMSK 1MB



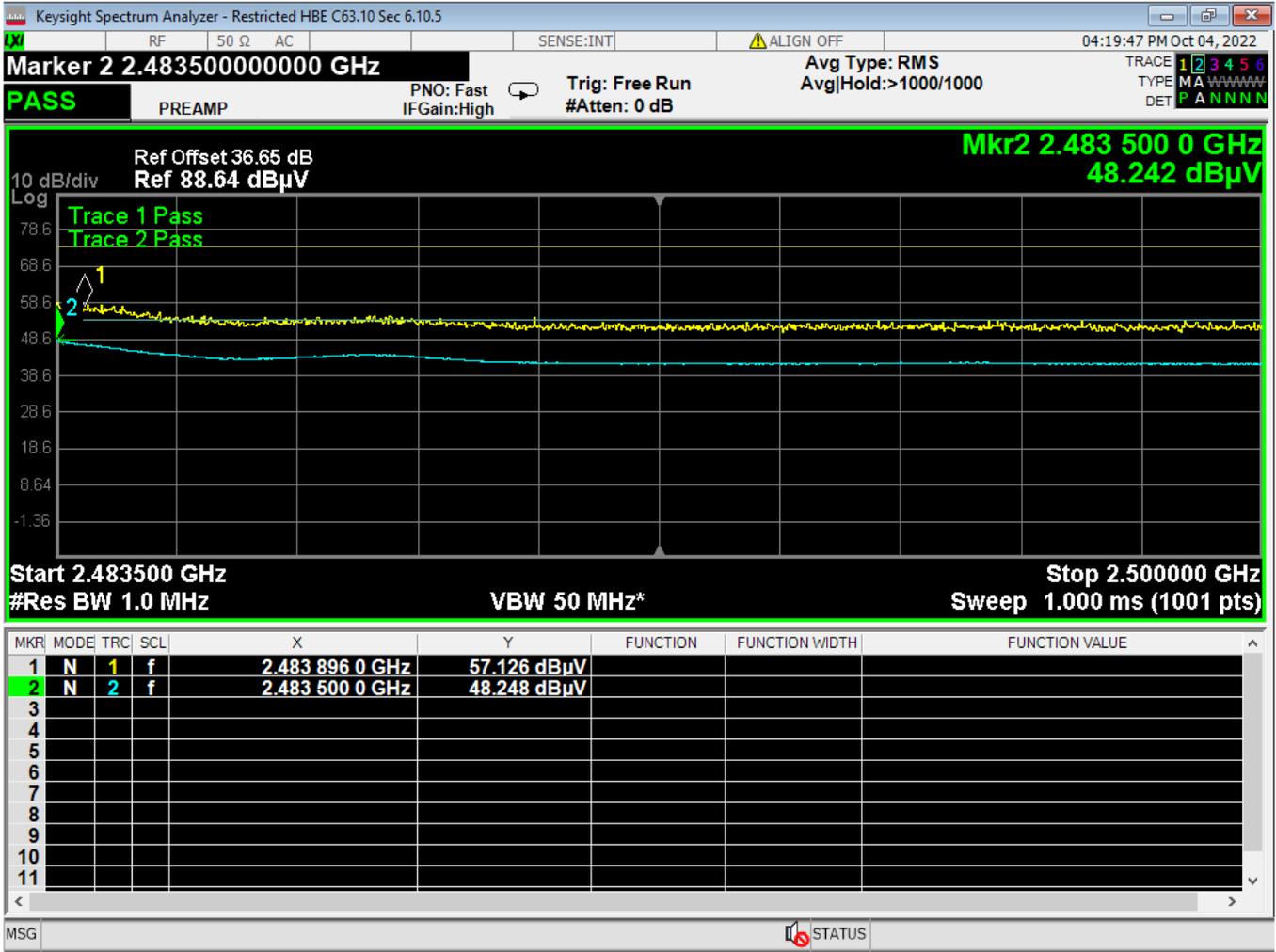
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



25 LBE, Restricted GMSK 1MB



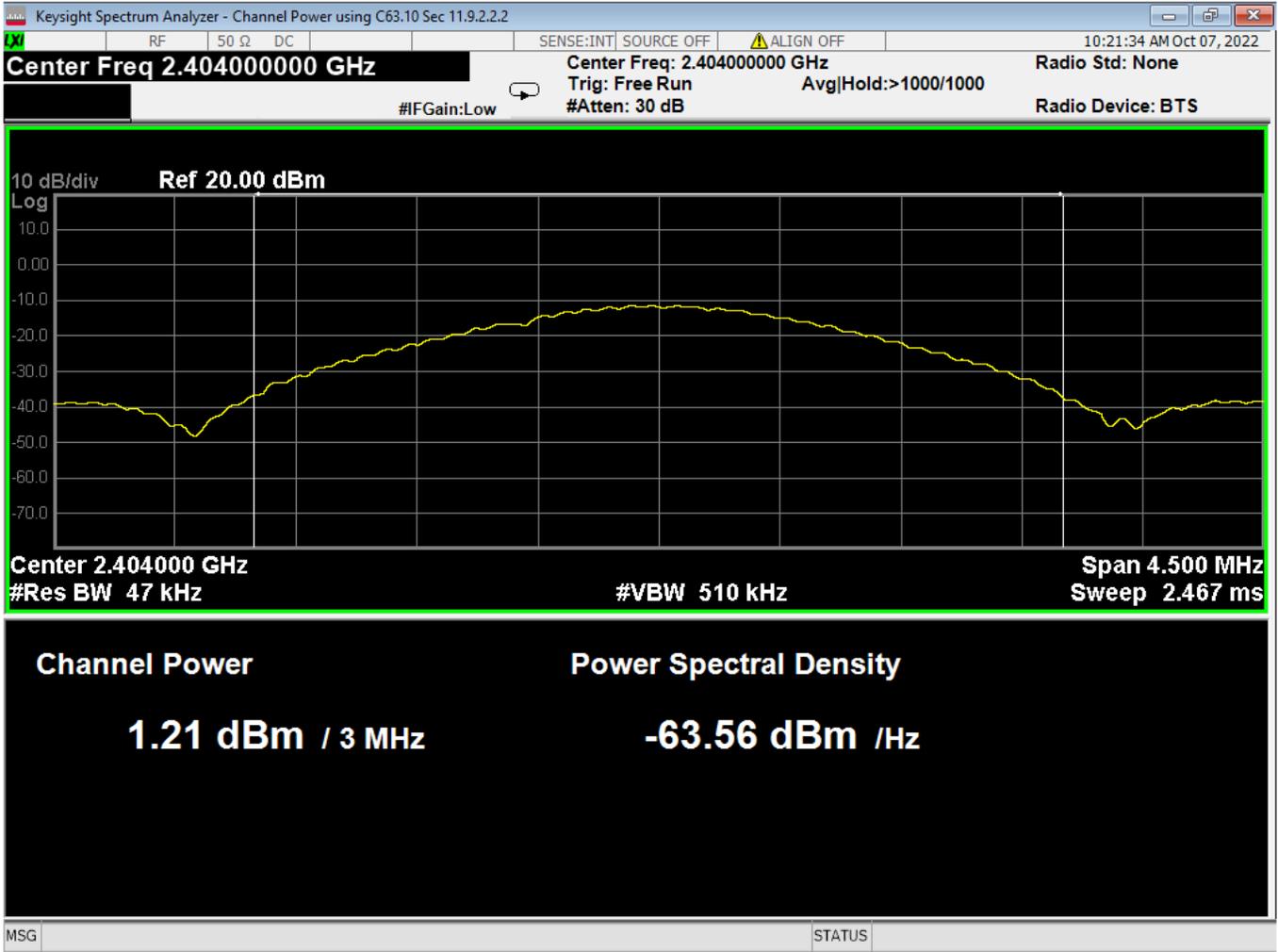
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



26 HBE, Restricted GMSK 1MB



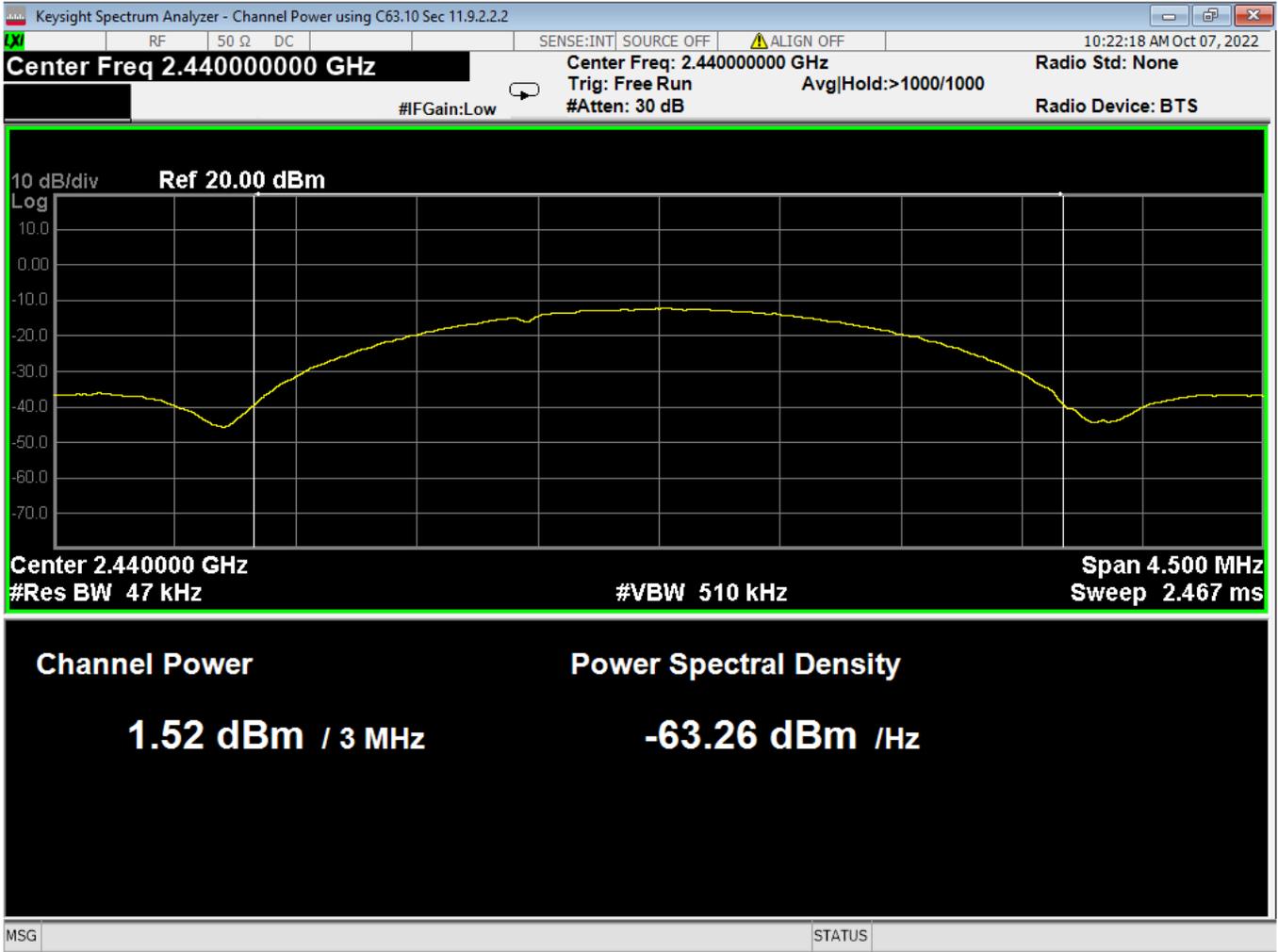
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



27 Average Power, Low Channel, GMSK 2MB



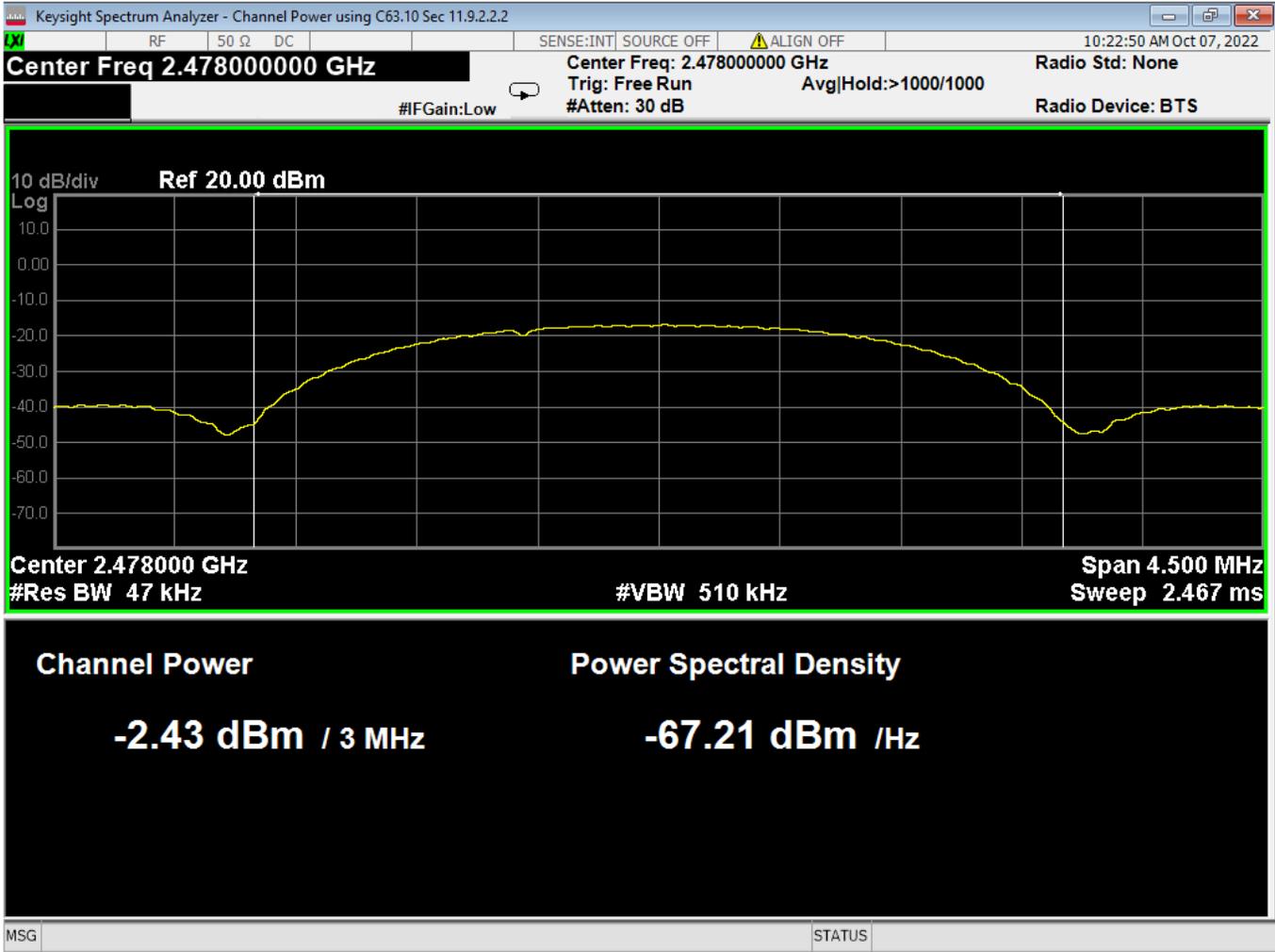
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



28 Average Power, Mid Channel, GMSK 2MB



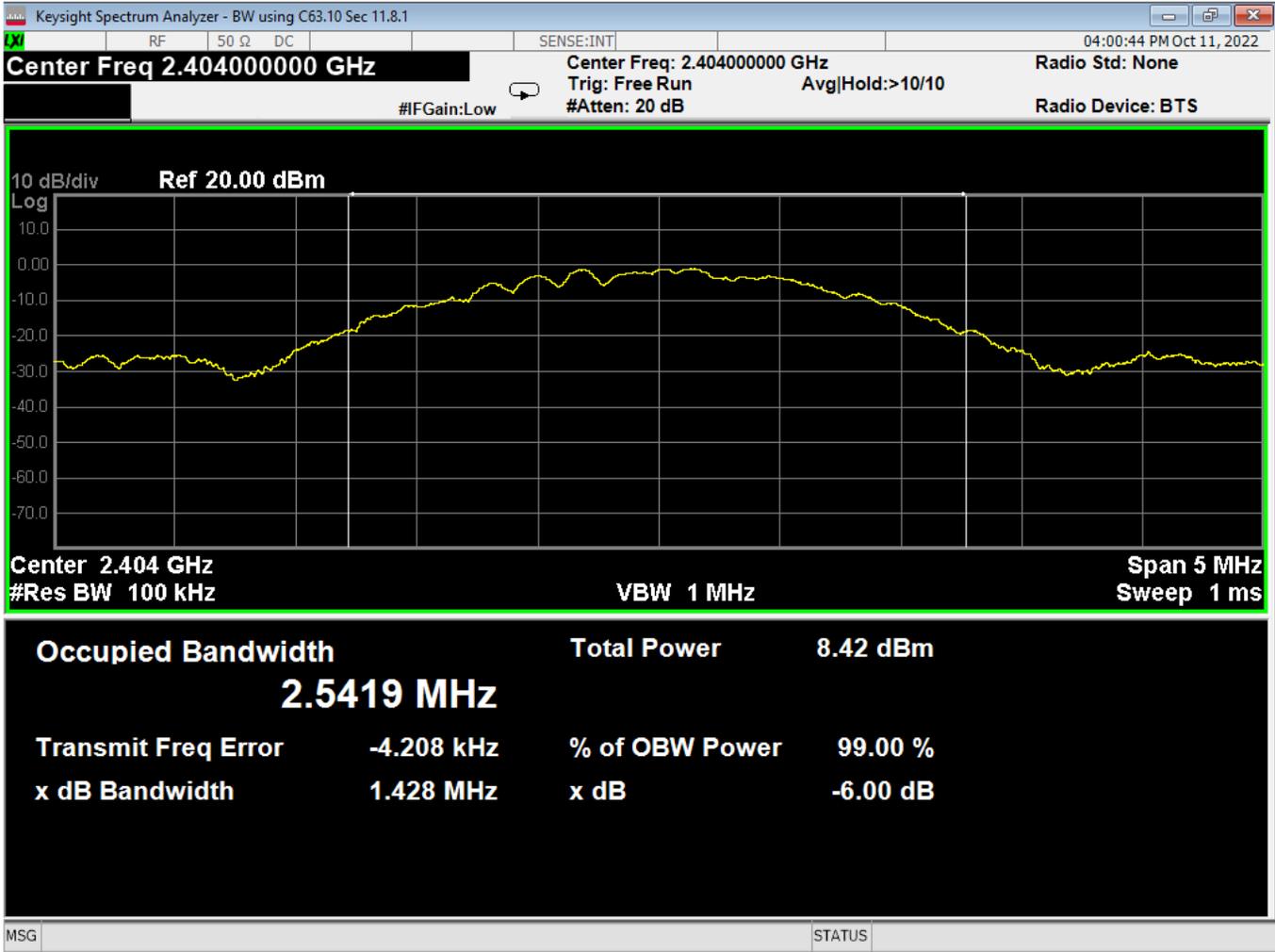
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



29 Average Power, High Channel, GMSK 2MB



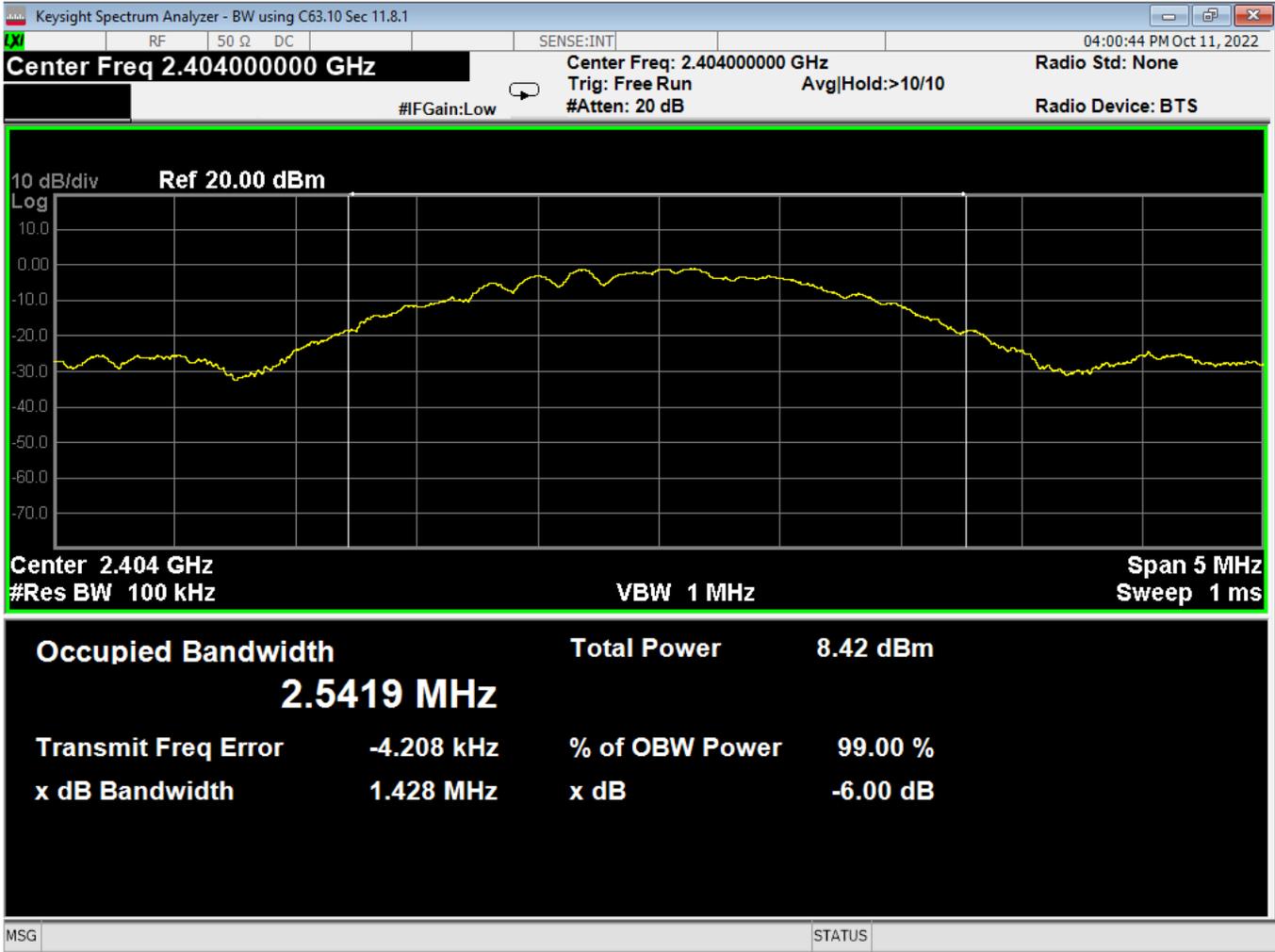
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



30 6dB Bandwidth, Low Channel, GMSK 2MB



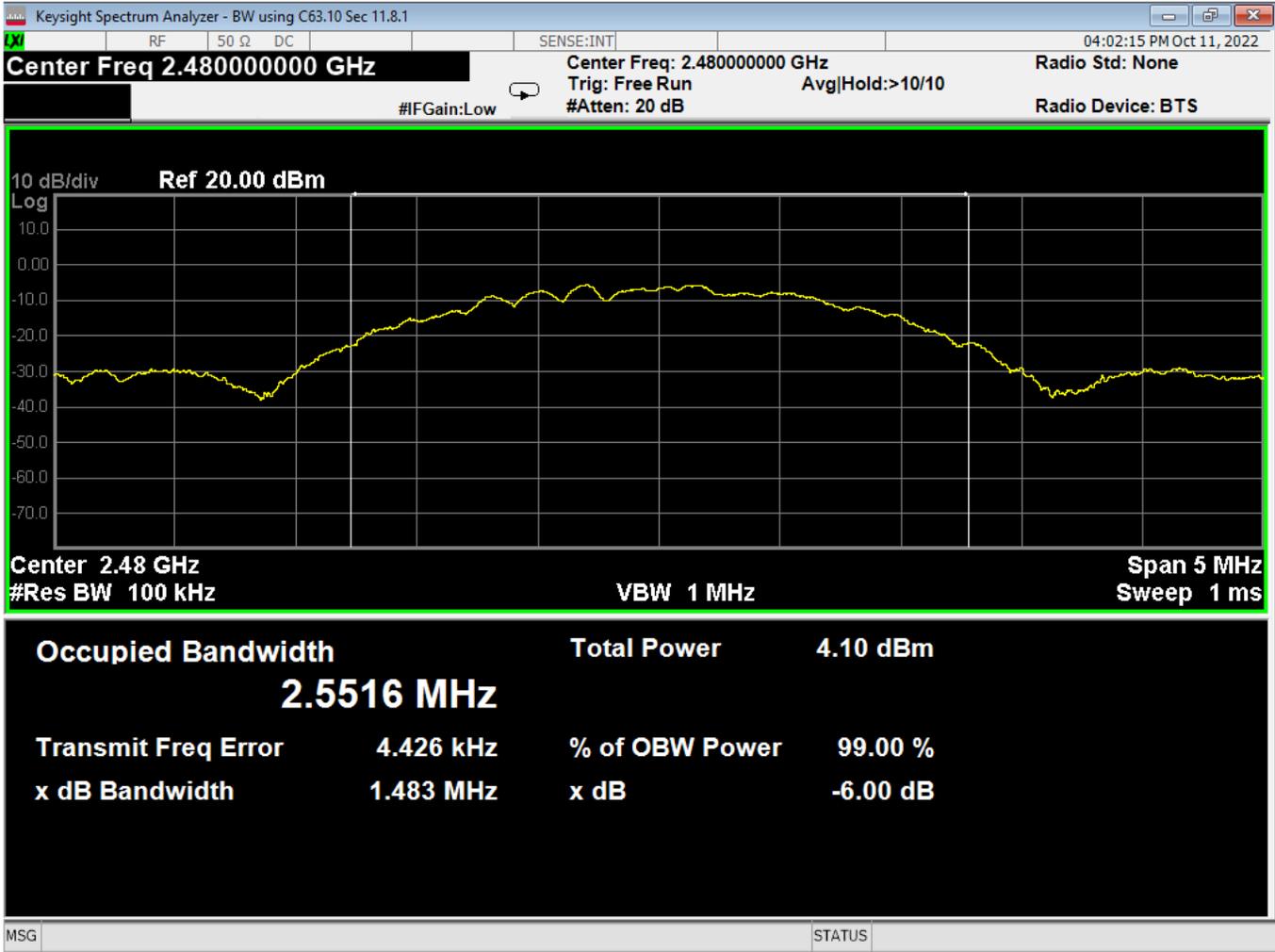
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



31 6dB Bandwidth, Mid Channel, GMSK 2MB



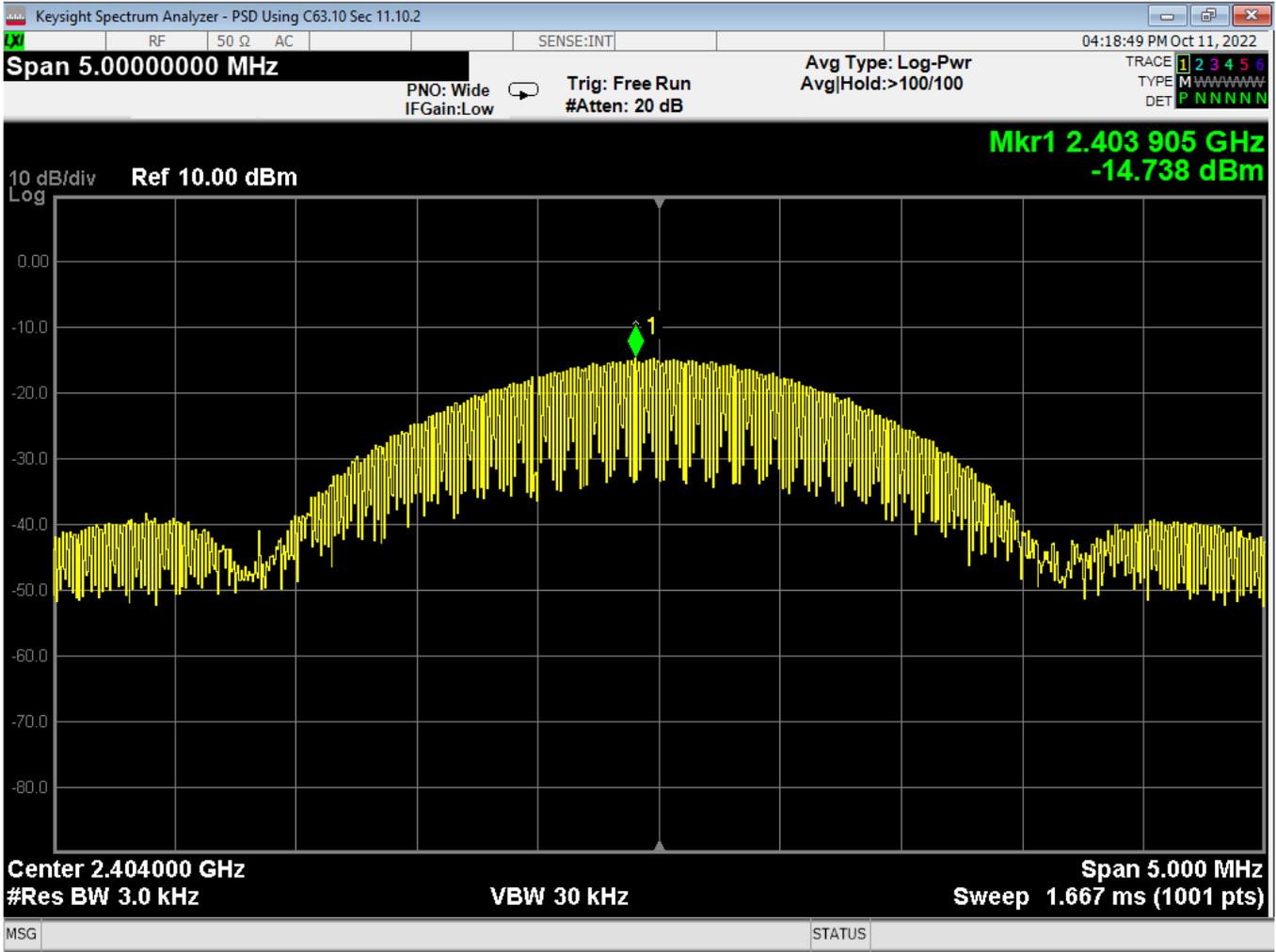
Report Number:	R20220901-21-E1C	Rev	B
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32 6dB Bandwidth, High Channel, GMSK 2MB



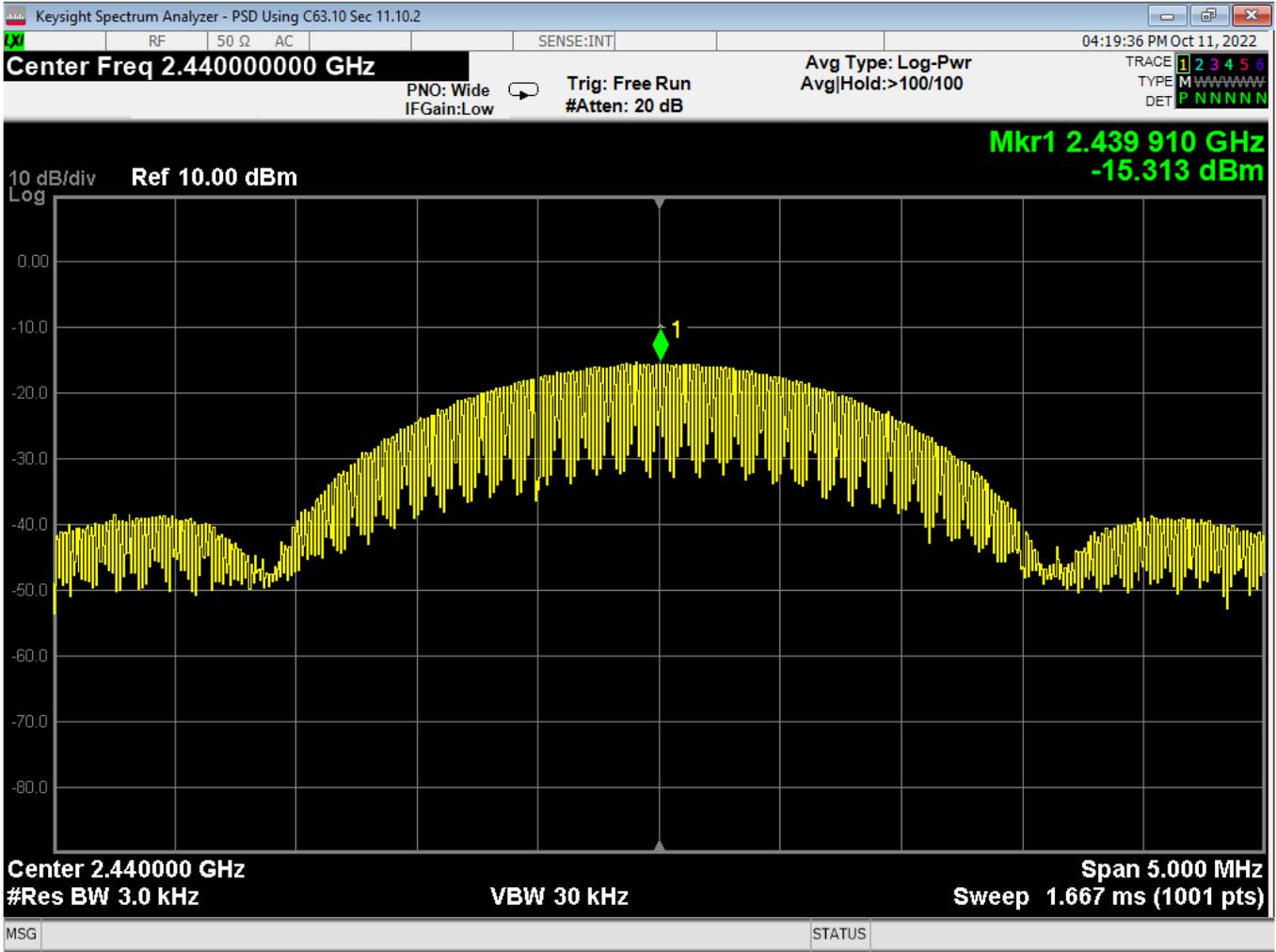
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



33 PSD, Low Channel, GMSK 2MB



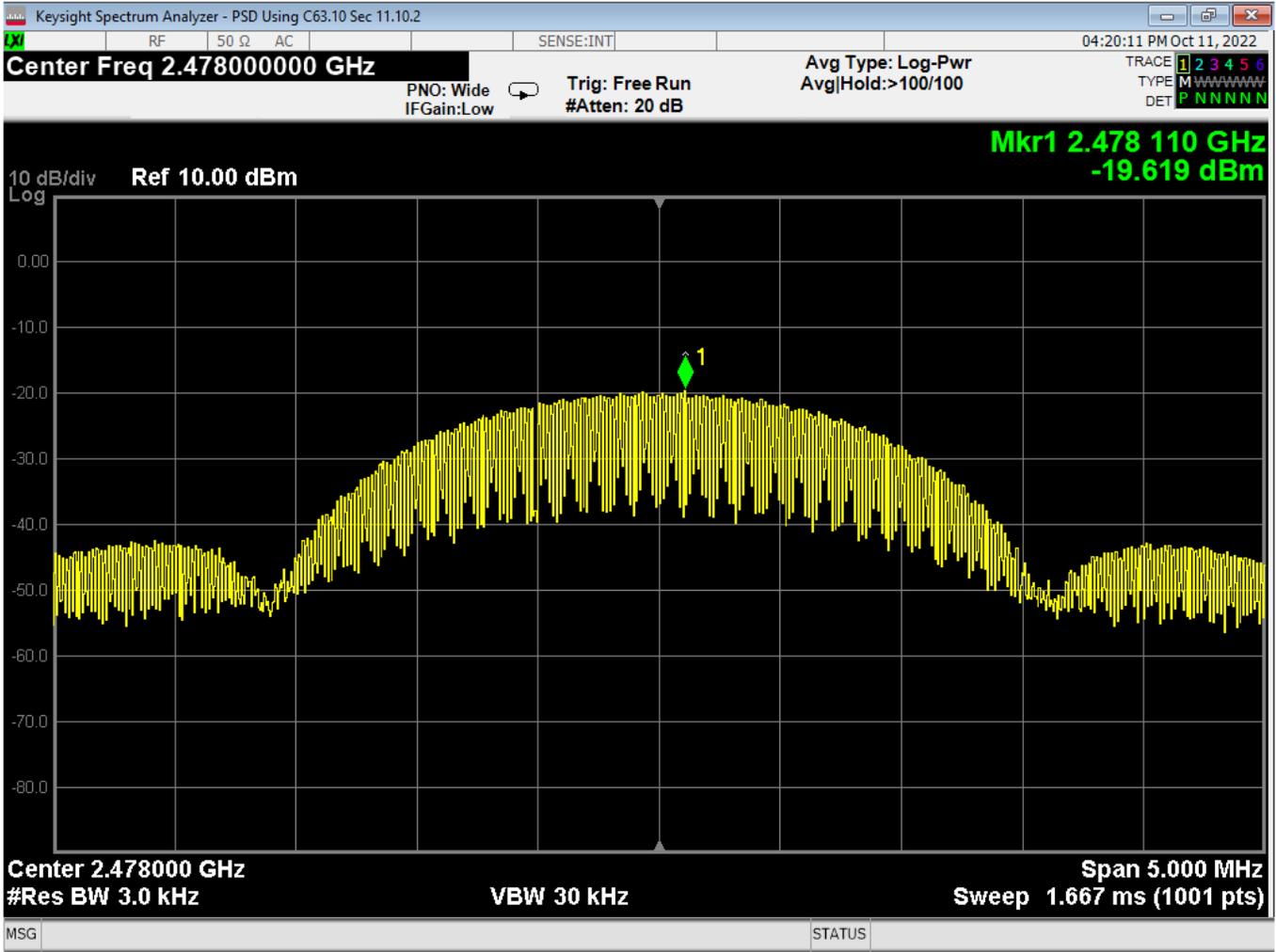
Report Number:	R20220901-21-E1C	Rev	B
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34 PSD, Mid Channel, GMSK 2MB



Report Number:	R20220901-21-E1C	Rev	B
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35 PSD, High Channel, GMSK 2MB



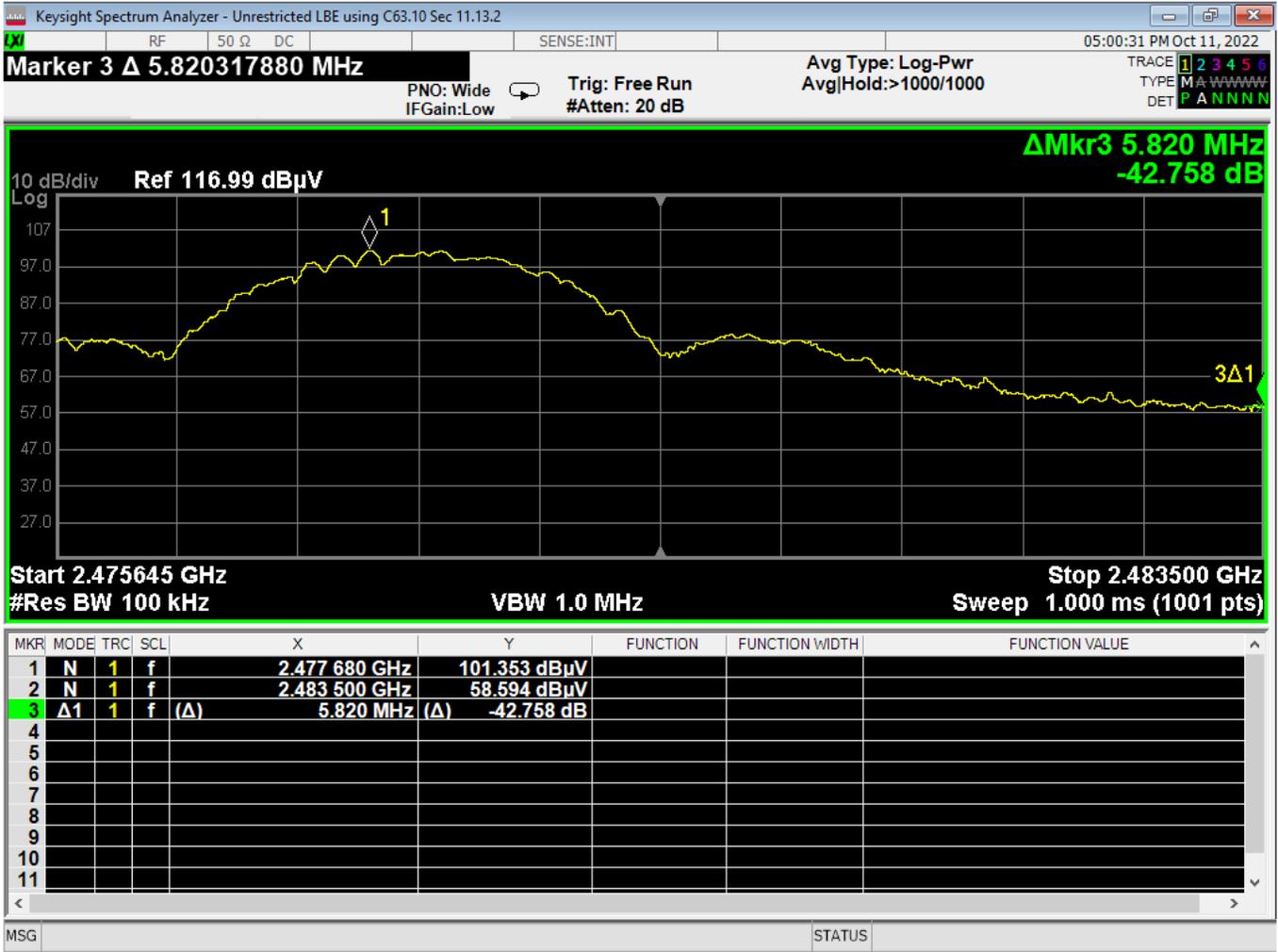
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



36 Lower Bandedge, Unrestricted, GMSK 2MB



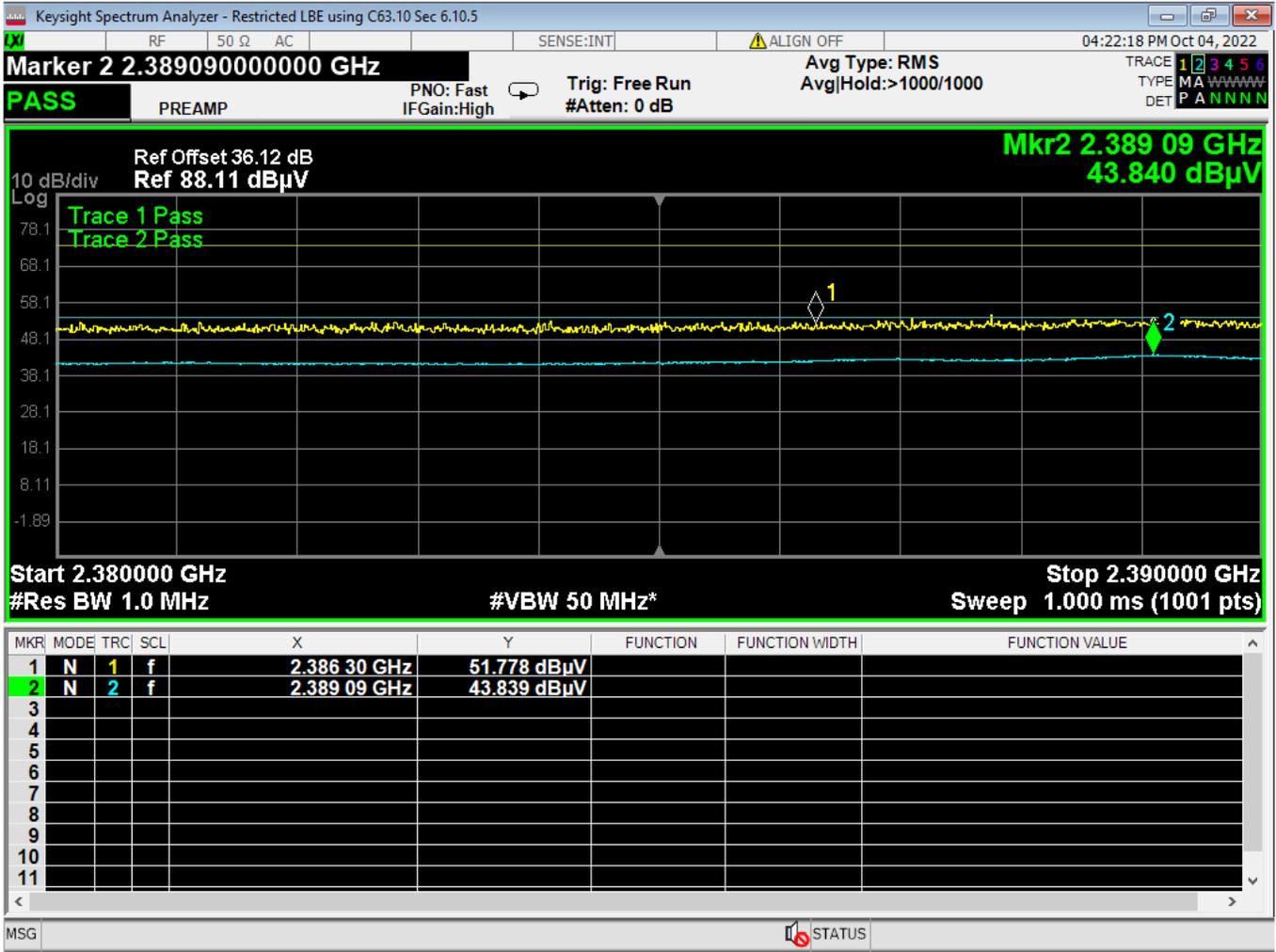
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



37 Higher Bandedge, Unrestricted, GMSK 2MB



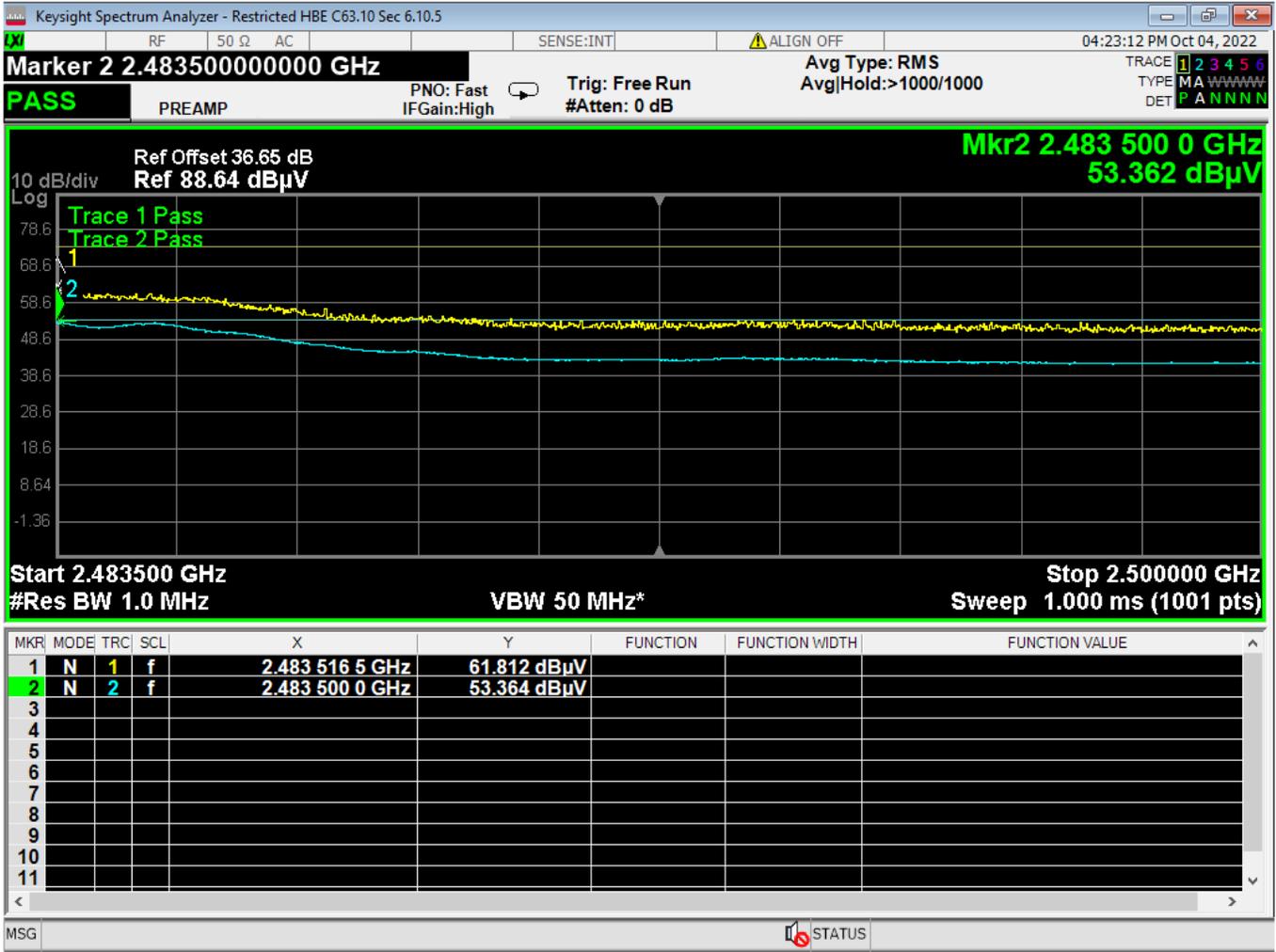
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



38 Lower Bandedge, Restricted, GMSK 2MB



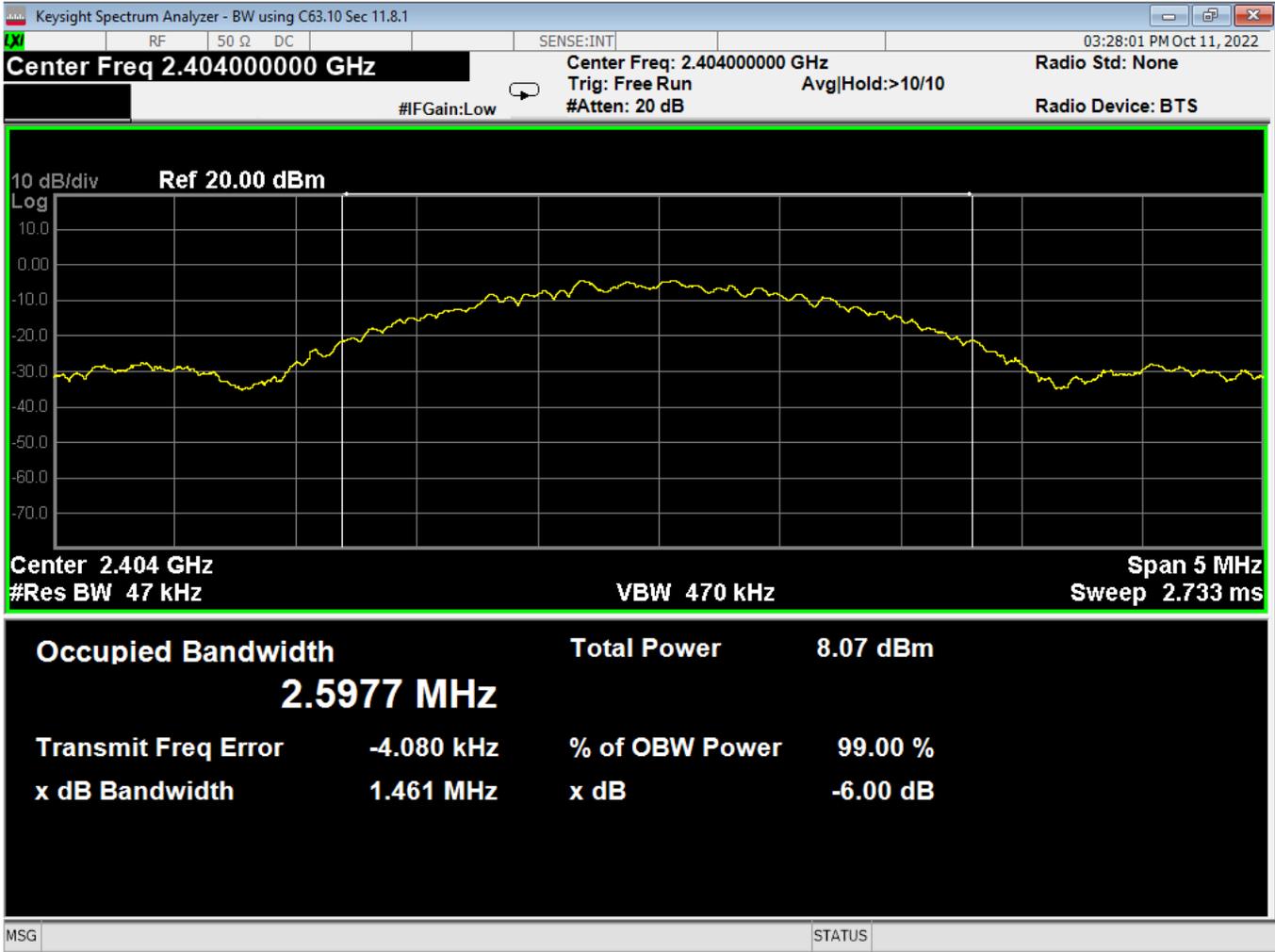
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



39 Higher Bandedge, Restricted, GMSK 2MB



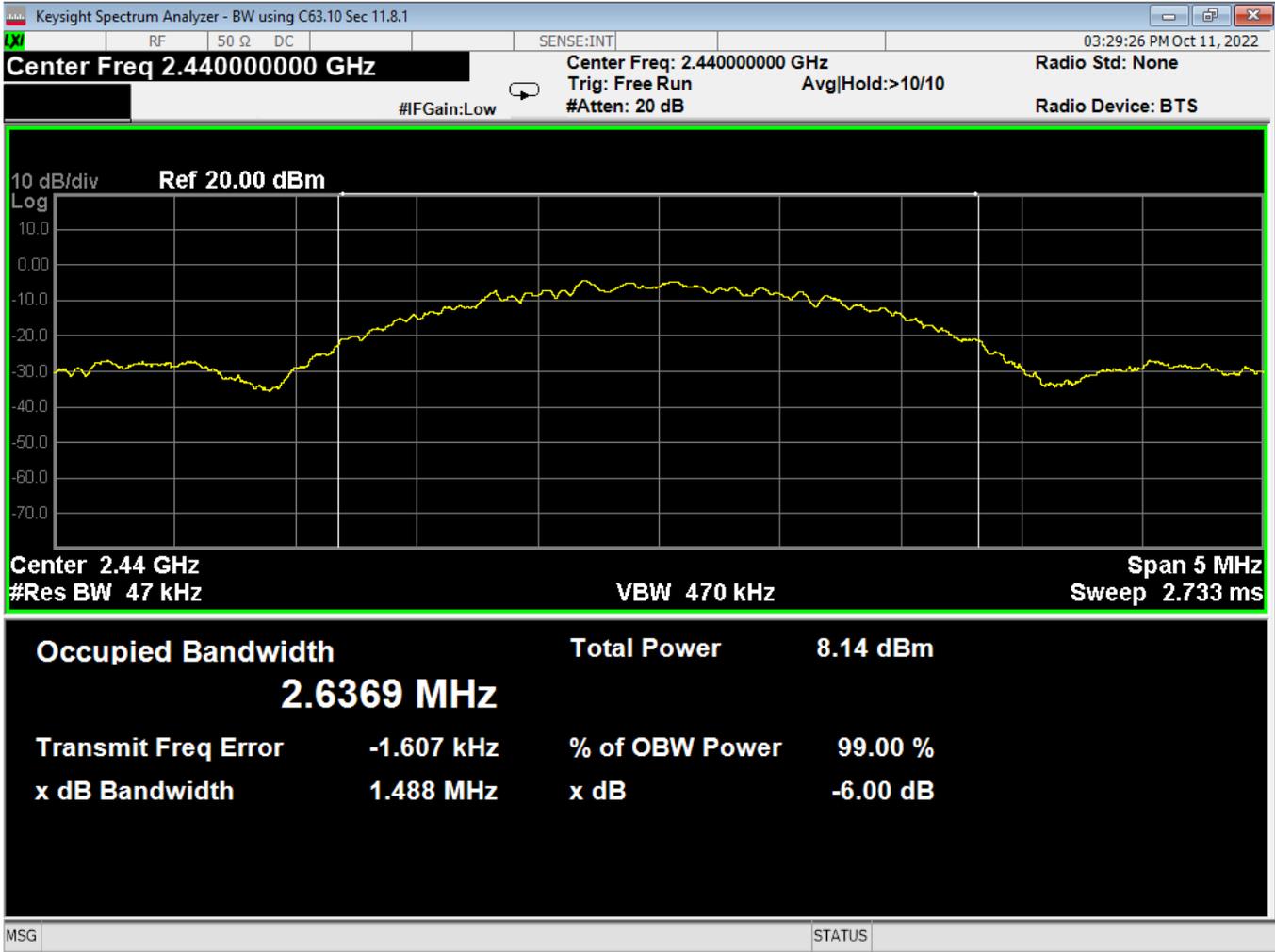
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



43 Occupied Bandwidth, Low Channel, GMSK 1MB



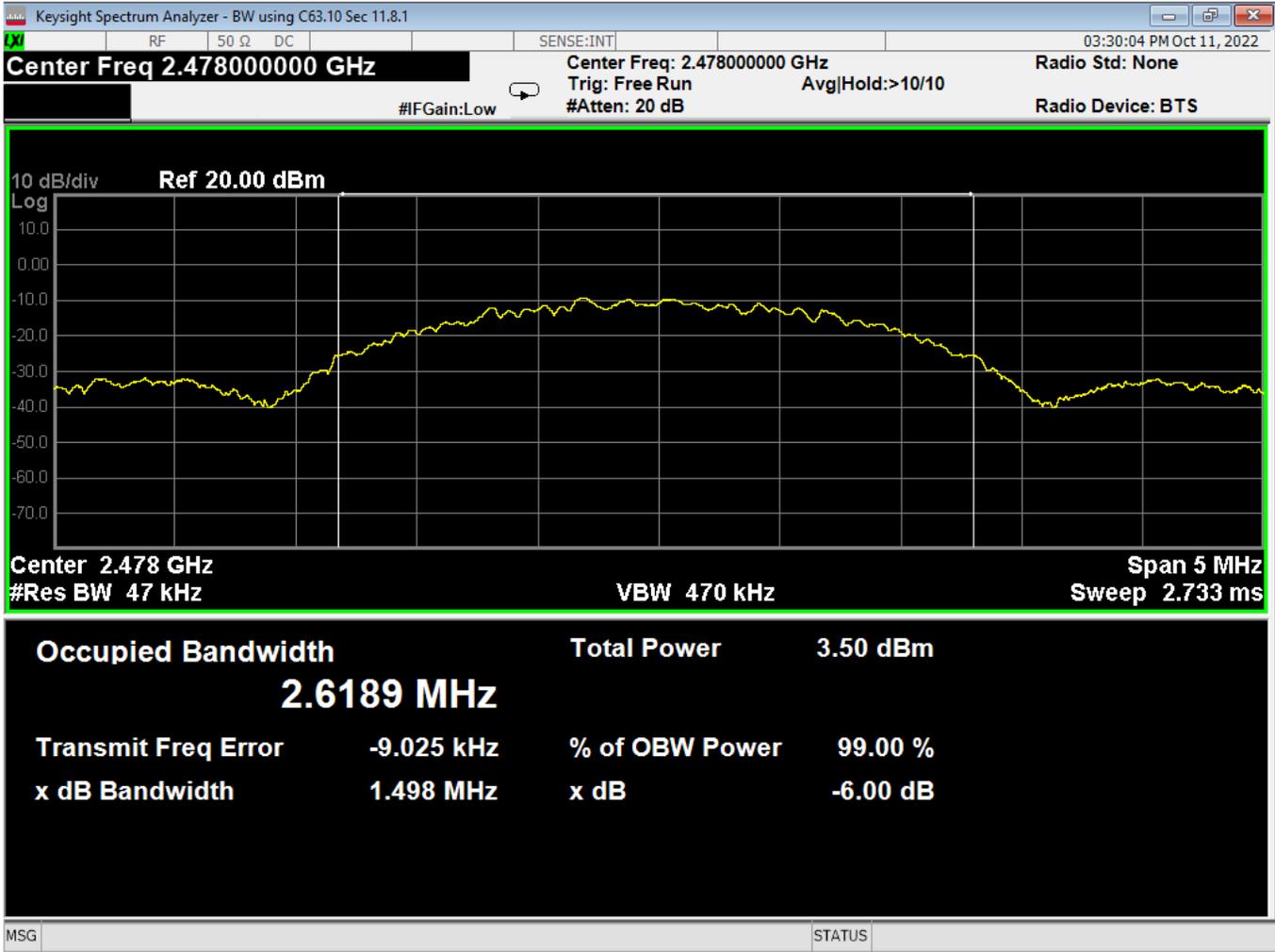
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



44 Occupied Bandwidth, Mid Channel, GMSK 1MB



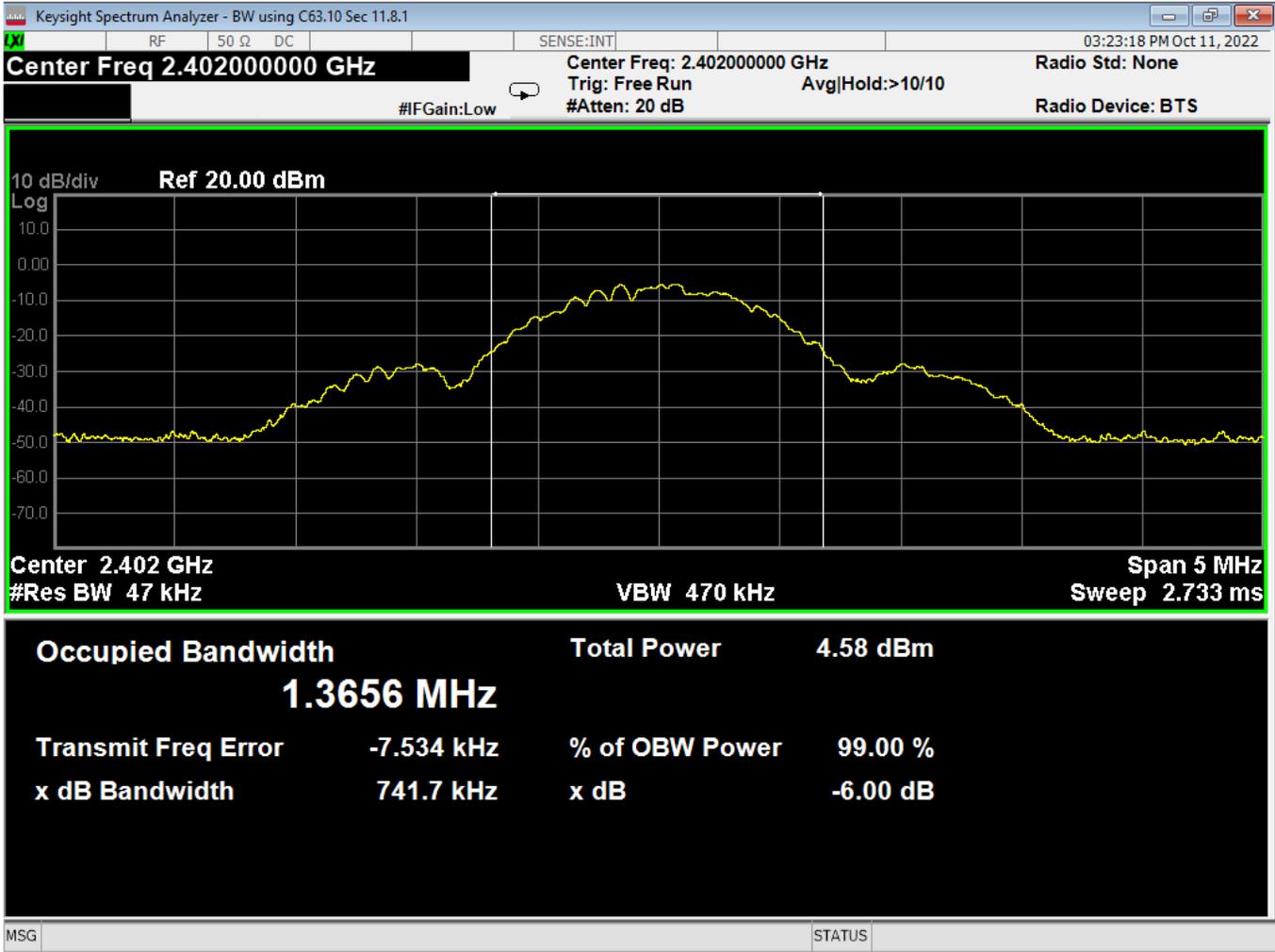
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



45 Occupied Bandwidth, High Channel, GMSK 1MB



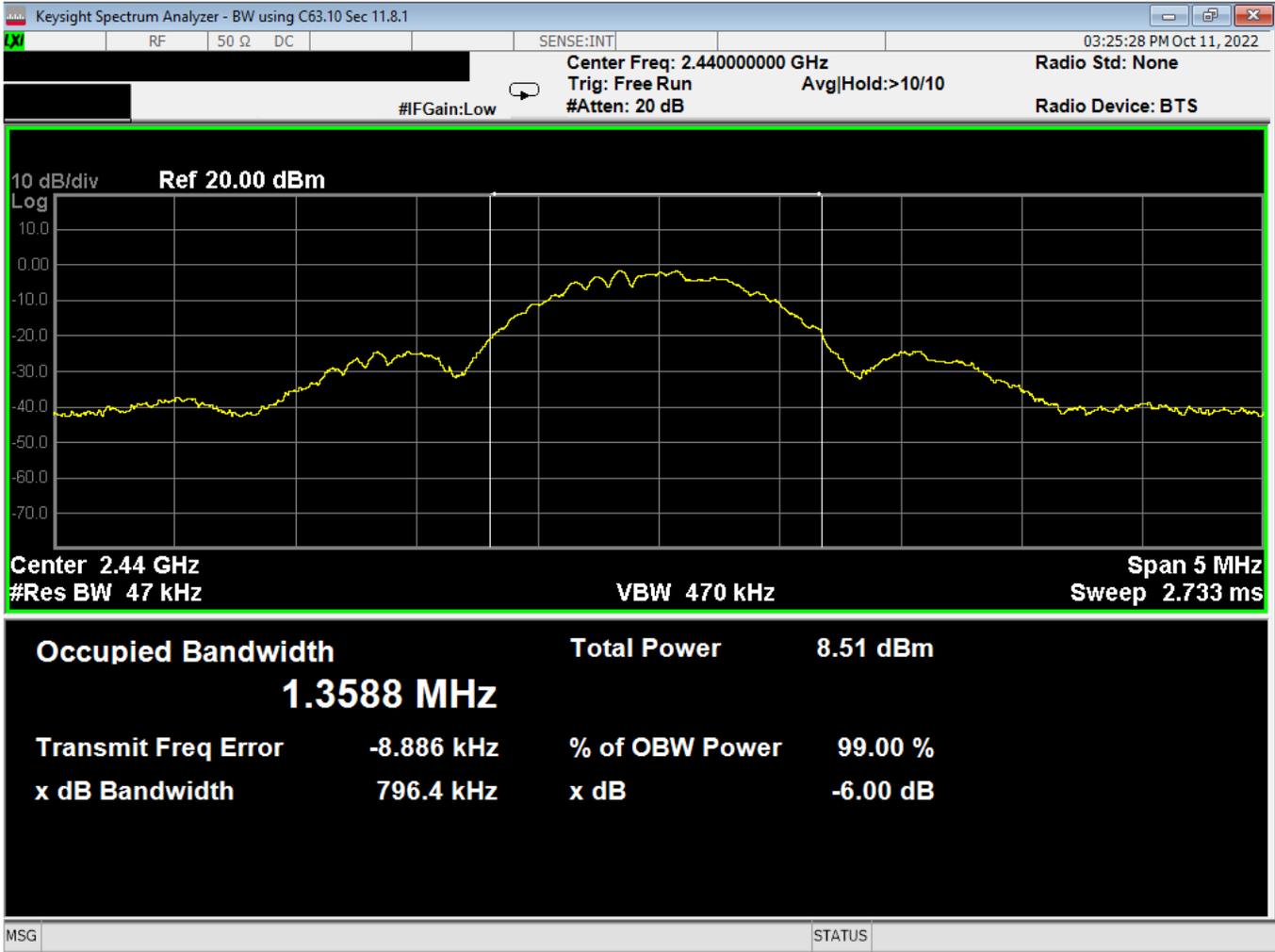
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



46 Occupied Bandwidth, Low Channel, GMSK 2MB



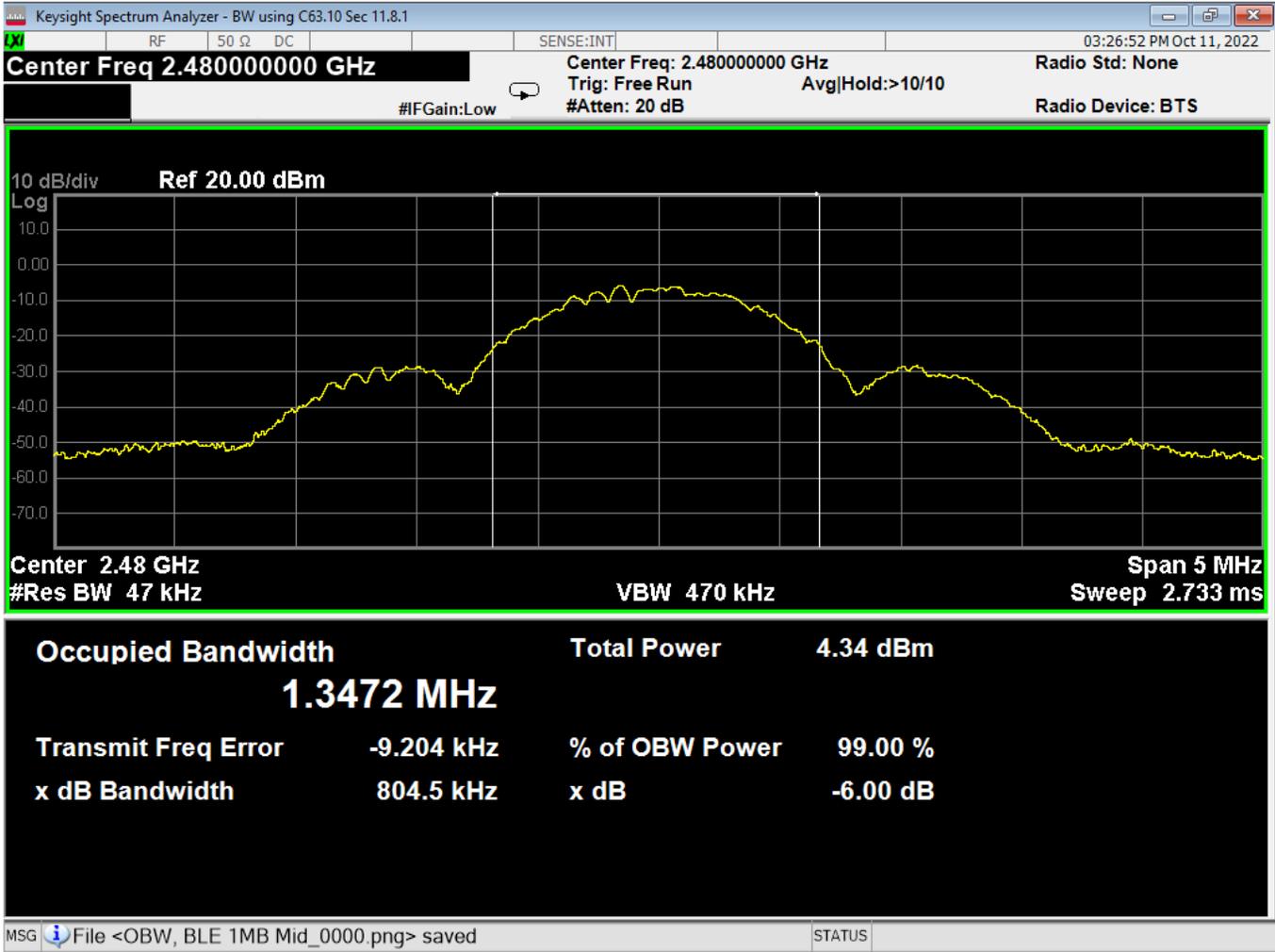
Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



47 Occupied Bandwidth, Mid Channel, GMSK 2MB



Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		



48 Occupied Bandwidth, High Channel, GMSK 2MB



Report Number:	R20220901-21-E1C	Rev	B
Prepared for:	Garmin International, Inc.		

REPORT END

## FCC/ISED Test Report

**Prepared for:** Garmin International, Inc.

**Address:** 1200 E. 151<sup>st</sup> Street  
Olathe, Kansas, 66062, USA

**Product:** A04452

**Test Report No:** R20220901-21-E3A

**Approved by:**



Fox Lane,  
EMC Test Engineer

**DATE:** December 6, 2022

**Total Pages:** 51

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Prepared for:	Garmin International, Inc.		

**REVISION PAGE**

<b>Rev. No.</b>	<b>Date</b>	<b>Description</b>
0	18 November 2022	Issued by FLane Reviewed by KVepuri Prepared by FLane, GLarsen
A	6 December 2022	Removed Antenna Gain - FL



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Prepared for:	Garmin International, Inc.		

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**1.0 SUMMARY OF TEST RESULTS**

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section (Please see the checked box below for the rule part used):

**FCC Part 15.247**

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15
- (2) ISED RSS-Gen, Issue 5
- (3) ISED RSS-247, Issue 2

APPLIED STANDARDS AND REGULATIONS		
Standard Section	Test Type	Result
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(b)(3) RSS-247 Issue 2 Section 5.4(d)	Peak output power	Pass
FCC Part 15.247(a)(2) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 5, Section 7.3	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 5, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(e) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 5.5	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass

## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

#### Summary and Operating Condition:

<b>EUT</b>	A04452
<b>IC</b>	1792A-04452
<b>FCC ID</b>	IPH-04452
<b>EUT Received</b>	3 October 2022
<b>EUT Tested</b>	3 October 2022- 7 November 2022
<b>Serial No.</b>	3426283485 (Radiated Measurements) 3426283465 (Conducted Measurements)
<b>Operating Band</b>	2400 – 2483.5 MHz
<b>Device Type</b>	<input type="checkbox"/> GMSK <input type="checkbox"/> GFSK <input type="checkbox"/> BT BR <input checked="" type="checkbox"/> BT EDR 2MB <input checked="" type="checkbox"/> BT EDR 3MB <input type="checkbox"/> 802.11x
<b>Power Supply / Voltage</b>	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: AQ27A-59CFA GPN: 362-00118-00 (Representative Power Supply)

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

### 2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

For Bluetooth Transmissions:

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

### 2.3 DESCRIPTION OF SUPPORT UNITS

None



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### 3.0 LABORATORY AND GENERAL TEST DESCRIPTION

#### 3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)  
 4740 Discovery Drive  
 Lincoln, NE 68521  
 A2LA Certificate Number: 1953.01  
 FCC Accredited Test Site Designation No: US1060  
 Industry Canada Test Site Registration No: 4294A-1  
 NCC CAB Identification No: US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of 35 ± 4%  
 Temperature of 22 ± 3° Celsius



#### 3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Karthik Vepuri	Test Engineer	Review
2	Fox Lane	Test Engineer	Testing and Report
3	Blake Winter	Test Engineer	Testing
4	Grace Larsen	Test Engineer	Testing and Report
5	Ethan Schmidt	Test Technician	Testing

**Notes:**

All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.



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### 3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
EMCO Horn Antenna	3115	6416	July 28, 2021	July 28, 2022
EMCO Horn Antenna***	3116	2576	March 9, 2020	March 9, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preampfier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Rohde & Schwarz Preampfier**	TS-PR18	3545700803	August 22, 2022	August 22, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber***	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preampfier to antenna)*	MFR-57500	90-195-040	August 22, 2022	August 22, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

\*Internal Characterization

\*\*2 Year Cal Cycle

**Notes:**

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

### 3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMENTS

Measurement type presented in this report (Please see the checked box below):

#### Conducted

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

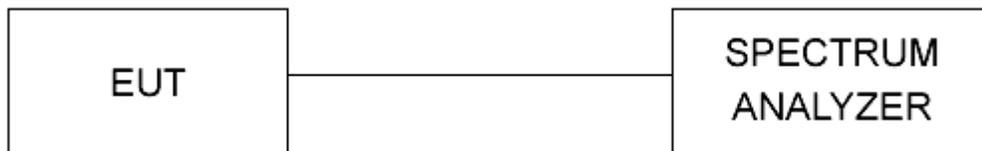


Figure 1 - Bandwidth Measurements Test Setup

#### Radiated

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

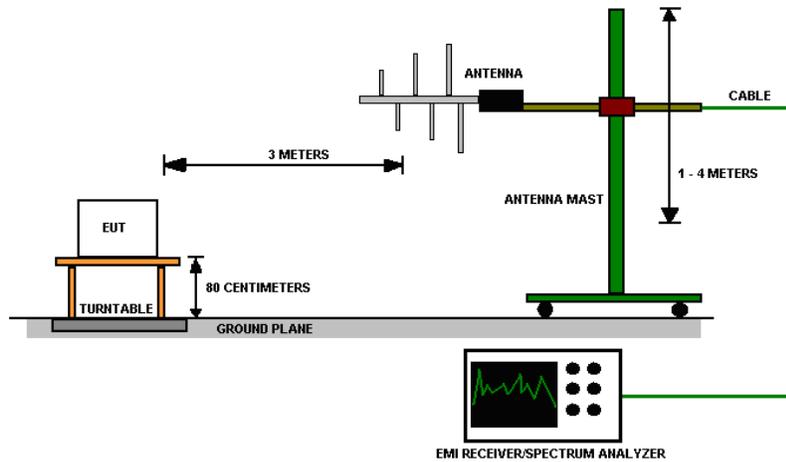


Figure 2 - Radiated Emissions Test Setup



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#### 4.0 RESULTS

DTS Radio Measurements							
CH.	Mode	Occupied Bandwidth (MHz)	6 dB Bandwidth (MHz)	AVG Output Power	AVG Output Power (mW)	PSD (dBm)	RESULT
Low	2EDR	1200.50	1066.00	8.920	7.798	-3.349	PASS
Mid	2EDR	1200.80	1066.00	8.460	7.015	-5.485	PASS
High	2EDR	1197.90	1065.00	9.290	8.492	-4.279	PASS
Low	3EDR	1238.80	970.40	8.450	6.998	-3.416	PASS
Mid	3EDR	1236.00	966.20	9.090	8.110	-4.106	PASS
High	3EDR	1239.20	970.00	8.840	7.656	-4.194	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit > 500 kHz				Peak Output Power Limit = 30 dBm; PSD Limit = 8 dBm			

Unrestricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamental (dBuV)	Delta (dB)	Min Delta (dB)	Result
Low	2EDR	2400.00	73.77	114.66	40.89	30.00	PASS
Low	3EDR	2400.00	72.34	114.16	41.82	30.00	PASS
High	2EDR	2483.50	54.89	114.26	59.38	30.00	PASS
High	3EDR	2483.50	56.17	114.32	58.15	30.00	PASS
Peak Restricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	2EDR	2390.00	53.42	Peak	73.98	20.56	PASS
Low	3EDR	2390.00	53.82	Peak	73.98	20.16	PASS
High	2EDR	2483.50	57.11	Peak	73.98	16.87	PASS
High	3EDR	2483.50	57.89	Peak	73.98	16.09	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							



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Average Restricted Band-Edge							
CH.	Mode	Band edge /Measurement Frequency (MHz)	Corrected Highest out of band level (dBuV/m @ 3m)**	Meas. Type	Limit (dBuV/m @ 3m)*	Margin	Result
Low	2EDR	2390	42.013	Average	53.98	11.967	PASS
Low	3EDR	2390	42.401	Average	53.98	11.579	PASS
<b>High</b>	<b>2EDR</b>	<b>2483.5</b>	<b>46.855</b>	<b>Average</b>	<b>53.98</b>	<b>7.125</b>	<b>PASS</b>
High	3EDR	2483.5	46.441	Average	53.98	7.539	PASS

\*Limit shown is the average limit taken from FCC Part 15.209



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#### 4.1 OUTPUT POWER

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, Sec. 11.9.2.2.4

**Limits of power measurements:**

**For FCC Part 15.247 Device:**

The maximum allowed output power is 30 dBm.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the output power plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables below.
4. Compiled values can be found in the Results section, 4.0.



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## 4.2 BANDWIDTH

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of bandwidth measurements:**

**For FCC Part 15.247 Device:**

The 99% occupied bandwidth is for informational purpose only. The 6dB bandwidth of the signal must be greater than 500 kHz.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the bandwidth plots can be found in the Appendix C.
2. All the measurements were found to be compliant.



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### 4.3 DUTY CYCLE

All modulation(s)/Transmitter(s) shown in this report have a duty cycle of >98%

#### 4.4 RADIATED EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.5, 6.6

**Limits for radiated emissions measurements:**

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ( $\mu\text{V/m}$ )	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

**NOTE:**

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) =  $20 * \log * \text{Emission level } (\mu\text{V/m})$ .
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.

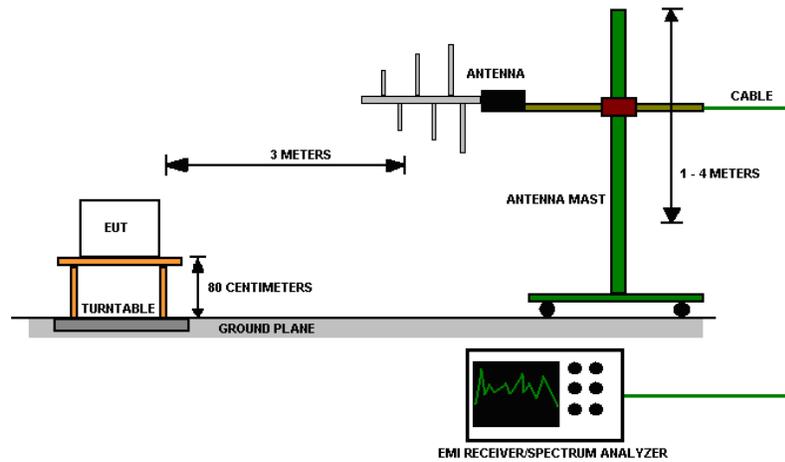


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**Test procedures:**

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

**Test setup:**



**Figure 3 - Radiated Emissions Test Setup**

**NOTE:**

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

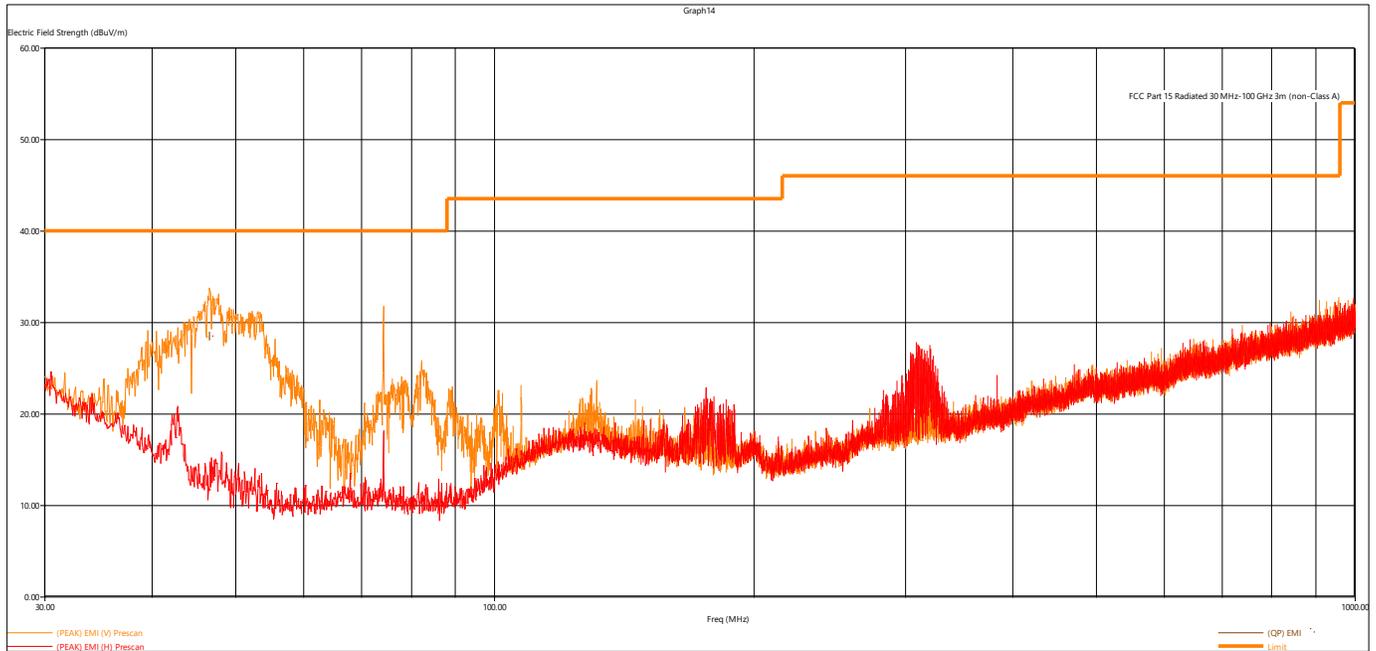
**Deviations from test standard:**

No deviation.

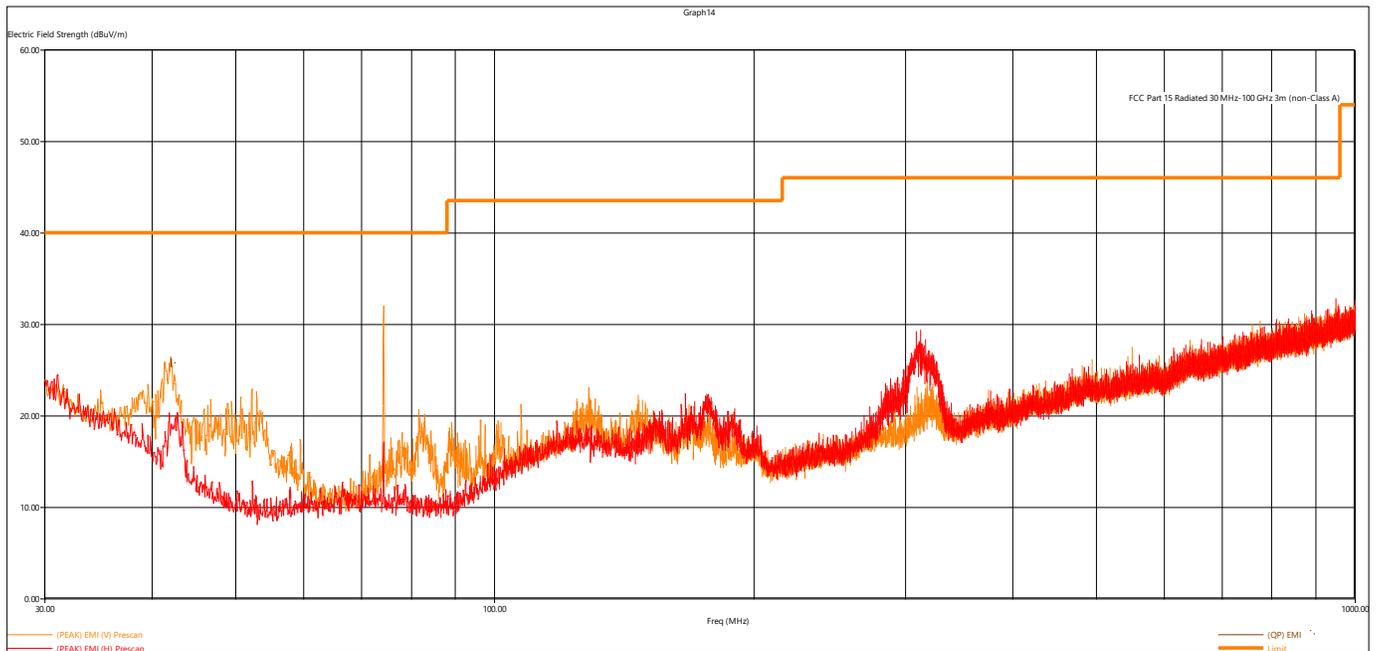
**EUT operating conditions**

Details can be found in section 2.1 of this report.

**Test results:**



**Figure 4 - Radiated Emissions Plot, Receive**



**Figure 5 - Radiated Emissions Plot, BT EDR 2MB**

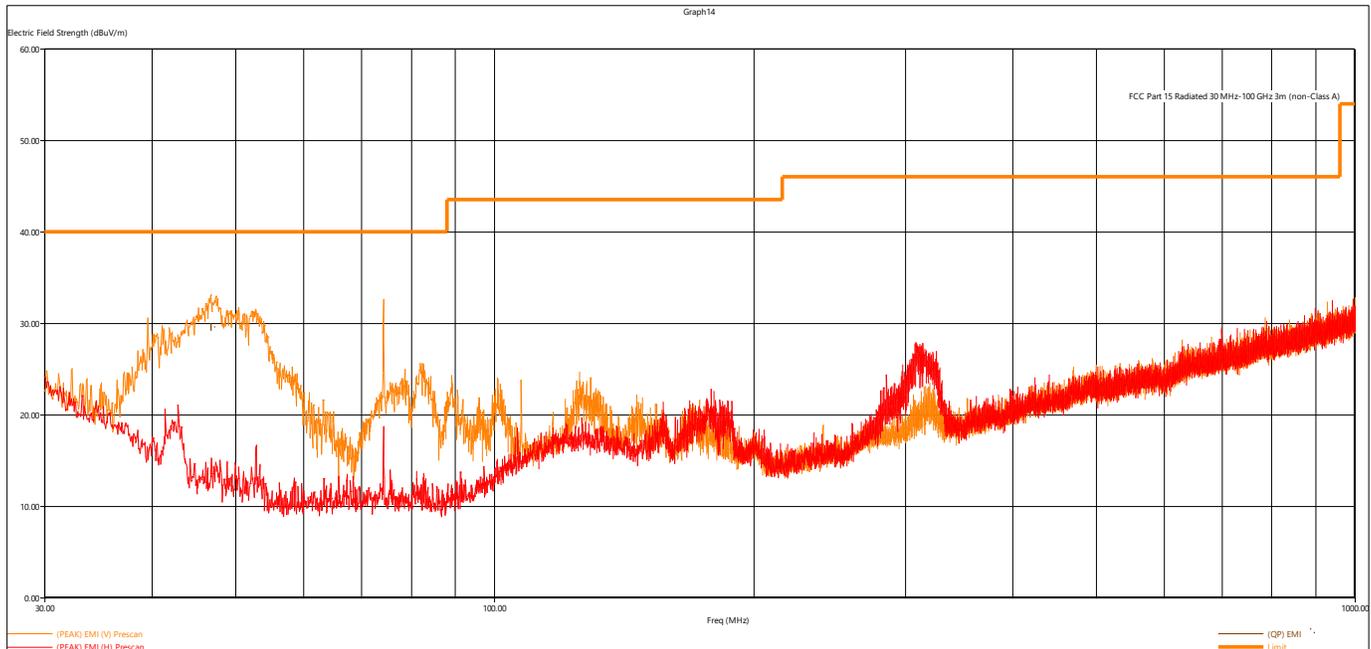


Figure 6 - Radiated Emissions Plot, BT EDR 3MB

**REMARKS:**

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

Quasi-Peak Measurements								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.			
41.875200	25.72	40.00	14.28	257.00	11.00	V	Low	2EDR
46.561200	29.56	40.00	10.44	105.00	176.00	V	Low	3EDR
46.431840	28.41	40.00	11.59	106.00	235.00	V	Rx	

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the table above.  
All other emissions found to be at least 6dB below limit line



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Peak Measurements								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.			
2402.140000	104.72	NA	NA	161.00	6.00	V	Low	BT EDR 2MB
2440.134000	105.77	NA	NA	187.00	358.00	V	Mid	BT EDR 2MB
2480.160000	106.17	NA	NA	175.00	5.00	V	High	BT EDR 2MB
2402.096000	104.64	NA	NA	162.00	6.00	V	Low	BT EDR 3MB
2439.830000	105.68	NA	NA	187.00	359.00	V	Mid	BT EDR 3MB
2479.810000	105.90	NA	NA	173.00	7.00	V	High	BT EDR 3MB

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the table above.  
All other emissions found to be at least 6dB below limit line

Average Measurements								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.			
2402.140000	103.32	NA	NA	161.00	6.00	V	Low	BT EDR 2MB
2440.134000	104.43	NA	NA	187.00	358.00	V	Mid	BT EDR 2MB
2480.160000	104.65	NA	NA	175.00	5.00	V	High	BT EDR 2MB
2402.096000	103.55	NA	NA	162.00	6.00	V	Low	BT EDR 3MB
2439.830000	104.23	NA	NA	187.00	359.00	V	Mid	BT EDR 3MB
2479.810000	104.32	NA	NA	173.00	7.00	V	High	BT EDR 3MB

All other emissions found to be at least 6dB below limit line

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the table above.  
All other emissions found to be at least 6dB below limit line



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#### 4.5 CONDUCTED SPURIOUS EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.7

**Limits of spurious emissions:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

**Test procedures:**

The highest emissions level was measured and recorded. All spurious measurements were evaluated to 20dB below the fundamental. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

None.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

Please note; the line shown in the plot is merely a reference line, not a limit line

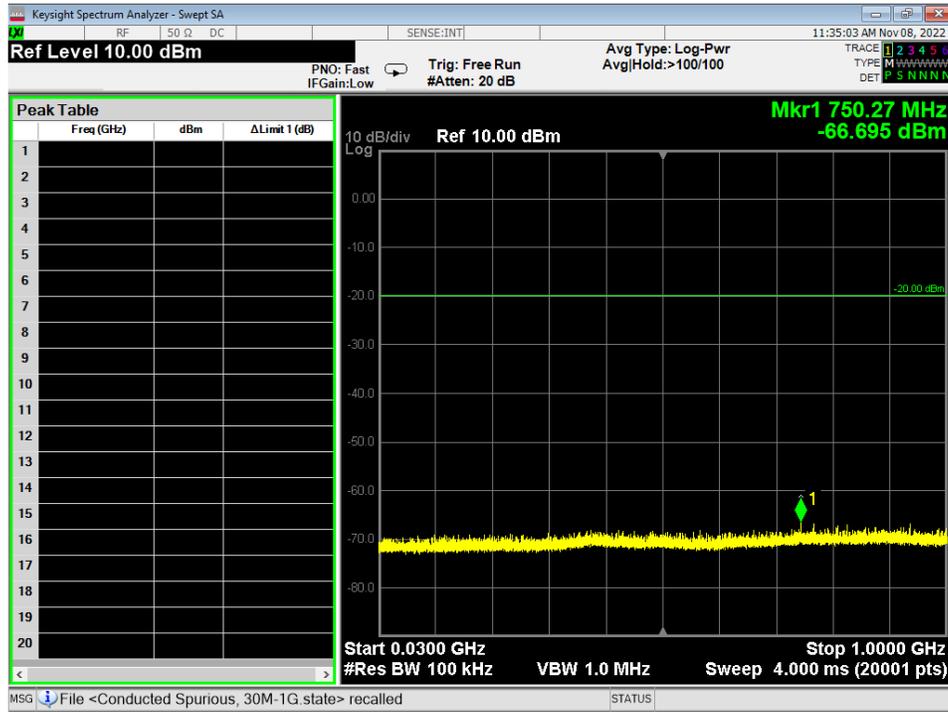


Figure 7 - Radiated Emissions Plot, 2EDR, 30M – 1G

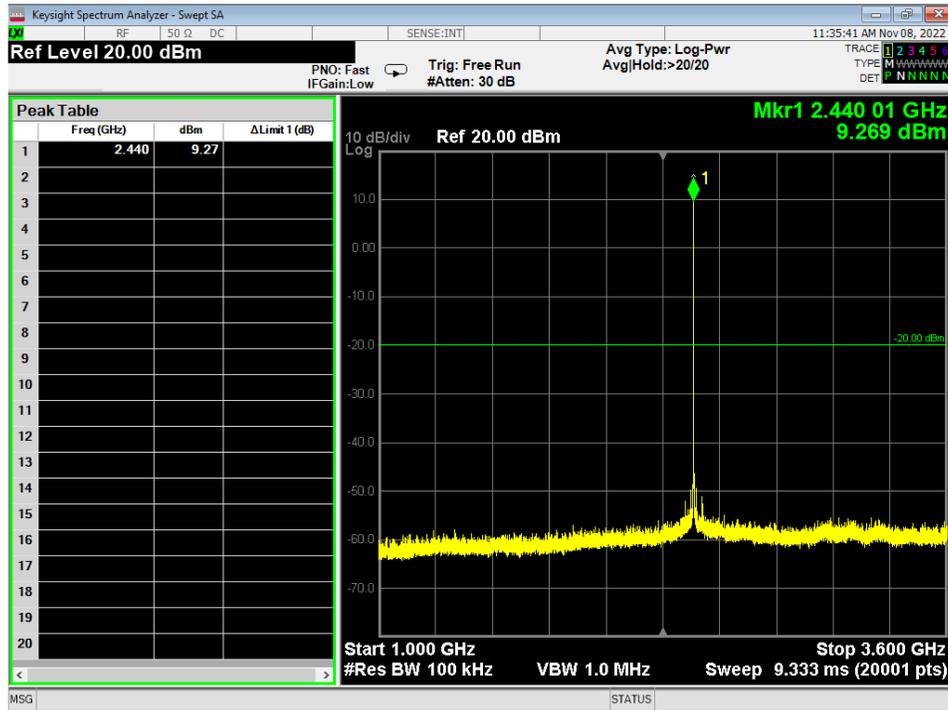


Figure 8 - Radiated Emissions Plot, 2EDR, 1G – 3.6G

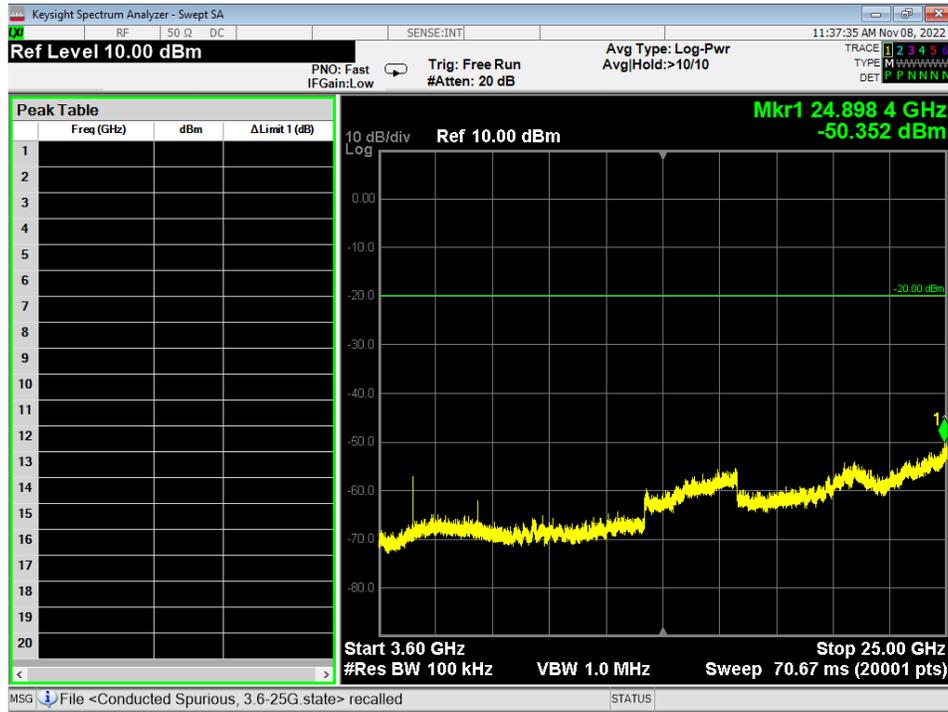


Figure 9 - Radiated Emissions Plot, 2EDR, 3.6G – 25G

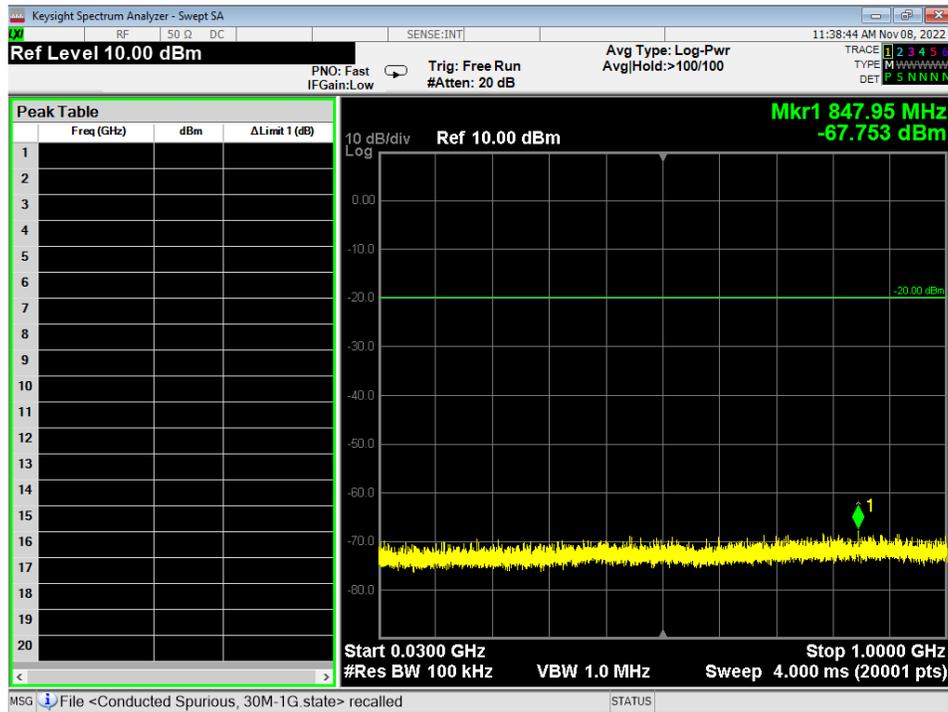


Figure 10 - Radiated Emissions Plot, 3EDR, 30M – 1G

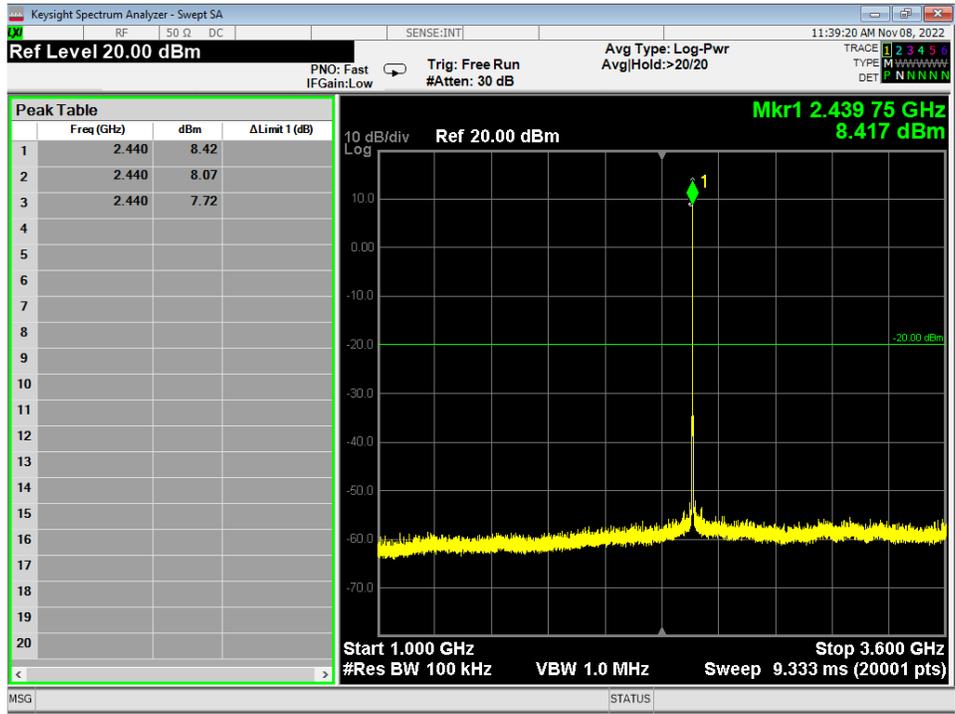


Figure 11 - Radiated Emissions Plot, 3EDR, 1G – 3.6G

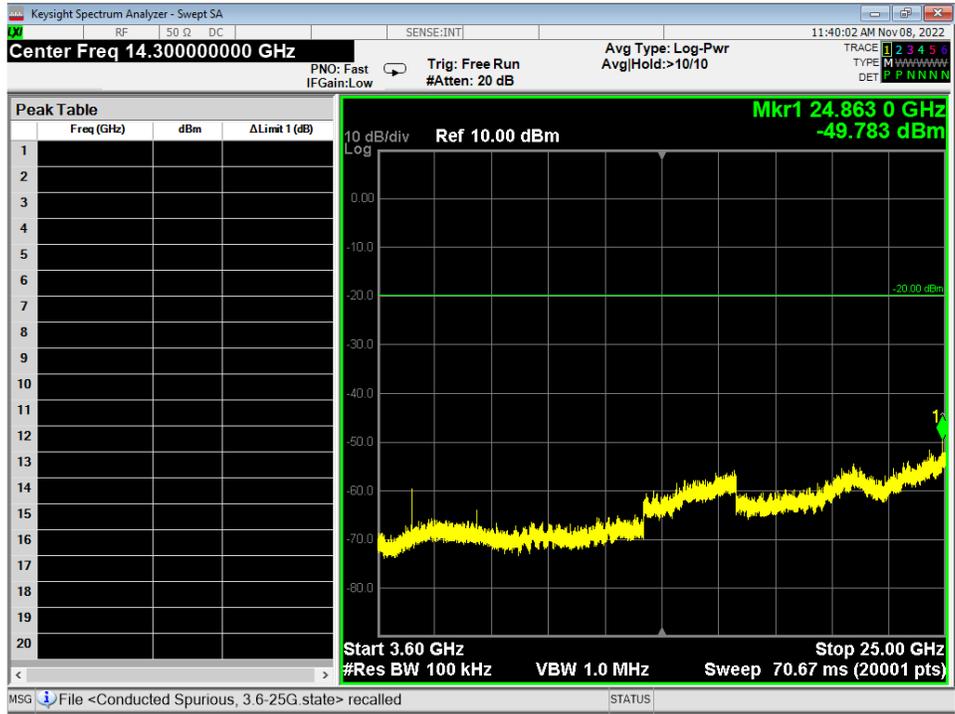


Figure 12 - Radiated Emissions Plot, 3EDR, 3.6G – 25G



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#### 4.6 BAND EDGES

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of band-edge measurements:**

**For FCC Part 15.247 Device:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

**Test procedures:**

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.



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**Test results:**

**Pass**

Comments:

1. All the band edge plots can be found in the Appendix C.
2. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.



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## 4.7 POWER SPECTRAL DENSITY

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of power measurements:**

**For FCC Part 15.247 Device:**

The maximum PSD allowed is 8 dBm.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the Power Spectral Density (PSD) plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are reported on the graph.



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## 4.8 CONDUCTED AC MAINS EMISSIONS

**Test Method:** ANSI C63.10, Section(s) 6.2

**Limits for conducted emissions measurements:**

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dB $\mu$ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

**Notes:**

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

**Test Procedures:**

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

**Deviation from the test standard:**

No deviation

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test Results:**



**Figure 13 - Conducted Emissions Plot, Line, TX**



**Figure 14 - Conducted Emissions Plot, Neutral, TX**



Figure 15 - Conducted Emissions Plot, Line, IDLE



Figure 16 - Conducted Emissions Plot, Neutral, IDLE



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## 4.9 ANTENNA GAIN

### Test procedures:

Device's conducted power was measured then the same measurement was repeated on a radiated sample at 3m test distance and converted to E.I.R.P.

### Test setup:

Details can be found in section 2.1 of this report.

### EUT operating conditions:

Details can be found in section 2.1 and 2.2 of this report.

### Test results:

#### Antenna Gain:

Radiated Average power – Conducted Average Power = Antenna gain

15.266 dBm – 17.78 dBm = **-2.514dBi**

#### Comments:

1. Data was used from a different transmitter (WIFI) that utilizes the same antenna and same frequency band
2. Since antenna gain found to be negative, conducted values are compared to limit where applicable

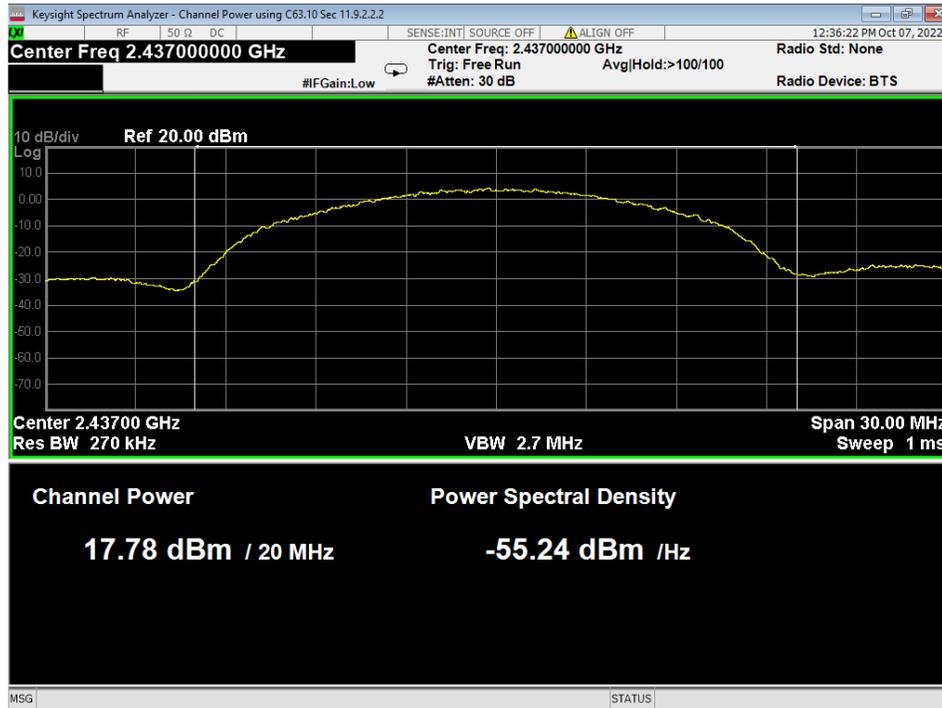


Figure 17 – Conducted Average Power Measurement, 802.11b 11MB

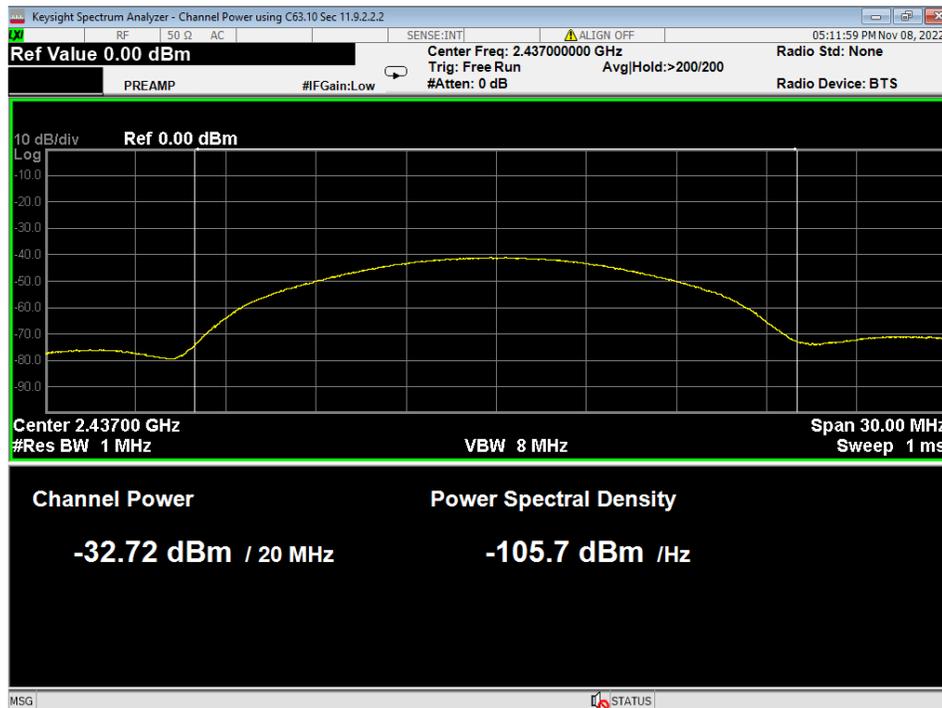


Figure 18 – Radiated Average Power Measurement, 802.11b 11MB

Value is uncorrected, see below for calculation  
 Radiated EIRP = Raw Field strength + 3m EIRP Conversion + Transducer + Cable Loss  
 $15.226 \text{ dBm} = -32.72 + 11.77 + 27.616 + 8.56$



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## APPENDIX A: SAMPLE CALCULATION

### Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

- RA = Receiver Amplitude
- AF = Antenna Factor
- CF = Cable Attenuation Factor
- AG = Amplifier Gain
- AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB $\mu$ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB $\mu$ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by the taking the  $20 \cdot \log(T_{on}/100)$  where  $T_{on}$  is the maximum transmission time in any 100ms window.



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**EIRP Calculations**

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

$$EIRP (Watts) = [Field Strength (V/m) \times antenna distance (m)]^2 / 30$$

$$Power (watts) = 10^{[Power (dBm)/10]} / 1000$$

$$Voltage (dB\mu V) = Power (dBm) + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$Field Strength (V/m) = 10^{[Field Strength (dB\mu V/m) / 20]} / 10^6$$

$$Gain = 1 \text{ (numeric gain for isotropic radiator)}$$

Conversion from 3m field strength to EIRP (d=3):

$$EIRP = [FS(V/m) \times d^2]/30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS(dB\mu V/m) - 95.23$$

*10log( 10^9) is the conversion from micro to milli*



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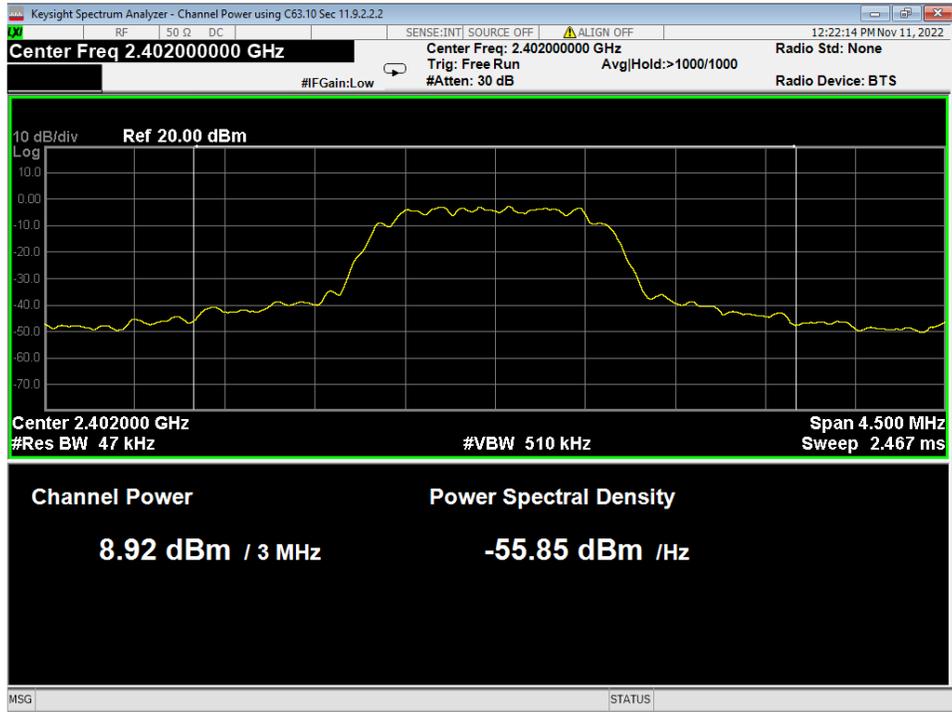
APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

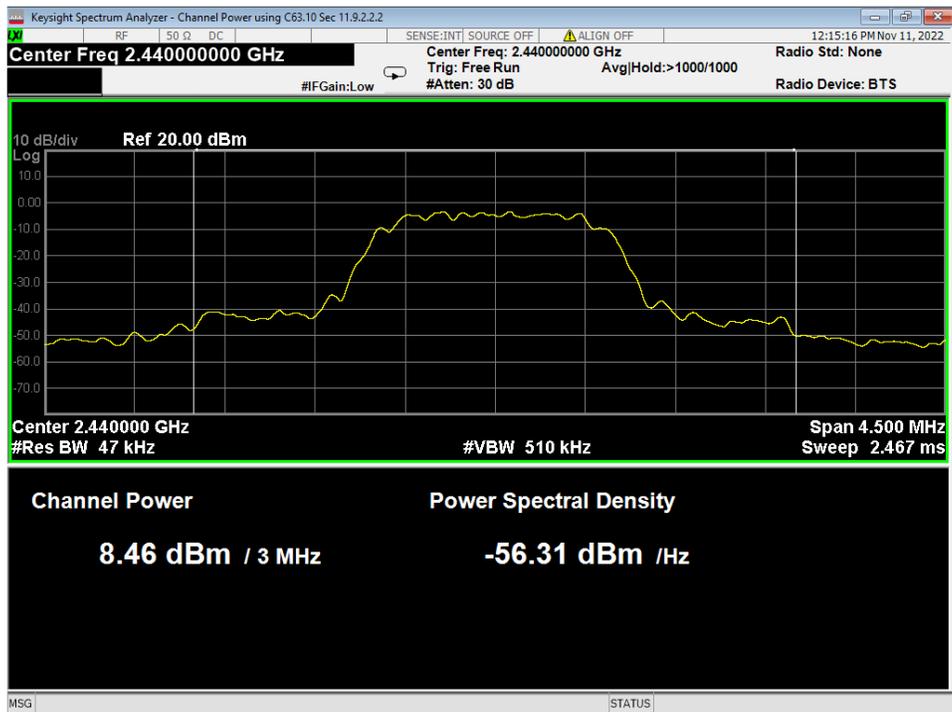
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

Expanded uncertainty values are calculated to a confidence level of 95%.

**APPENDIX C – GRAPHS AND TABLES**



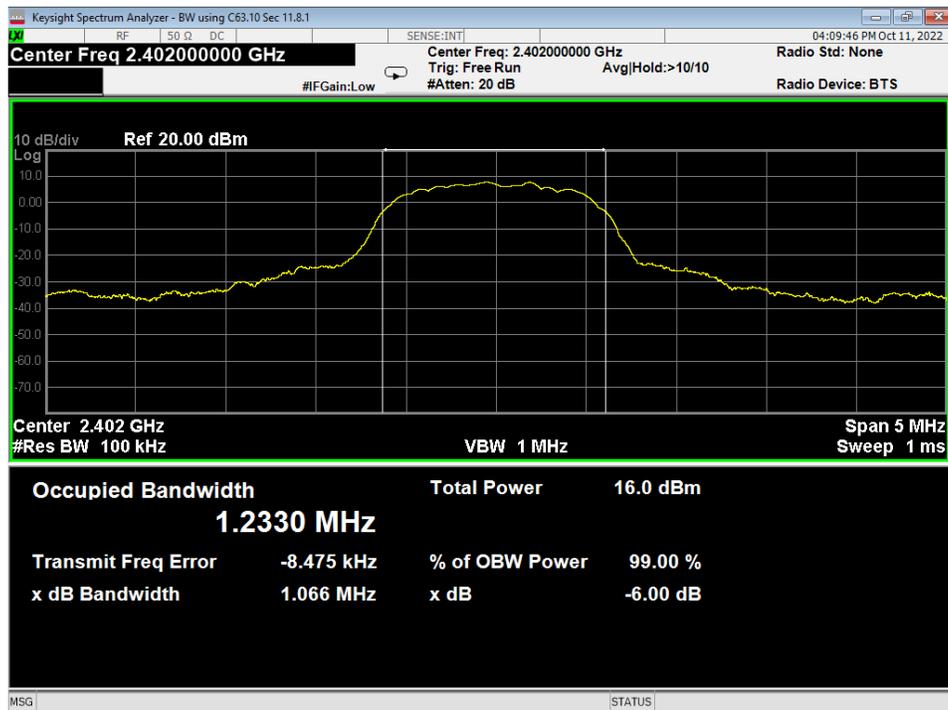
**01 Power, Low Channel, 2EDR**



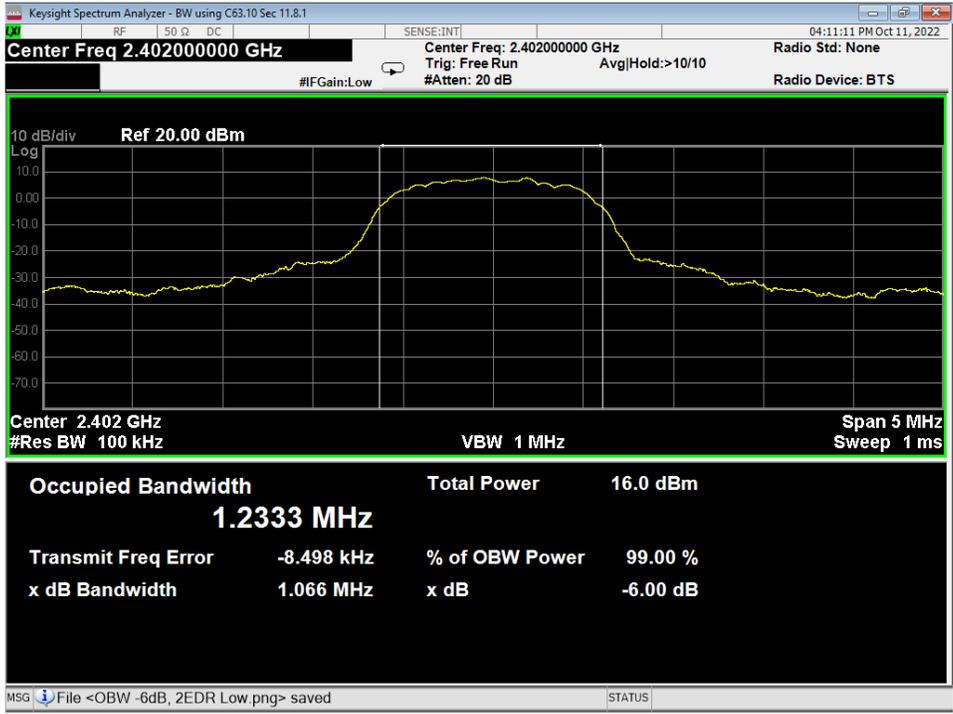
**02 Power, Mid Channel, 2EDR**



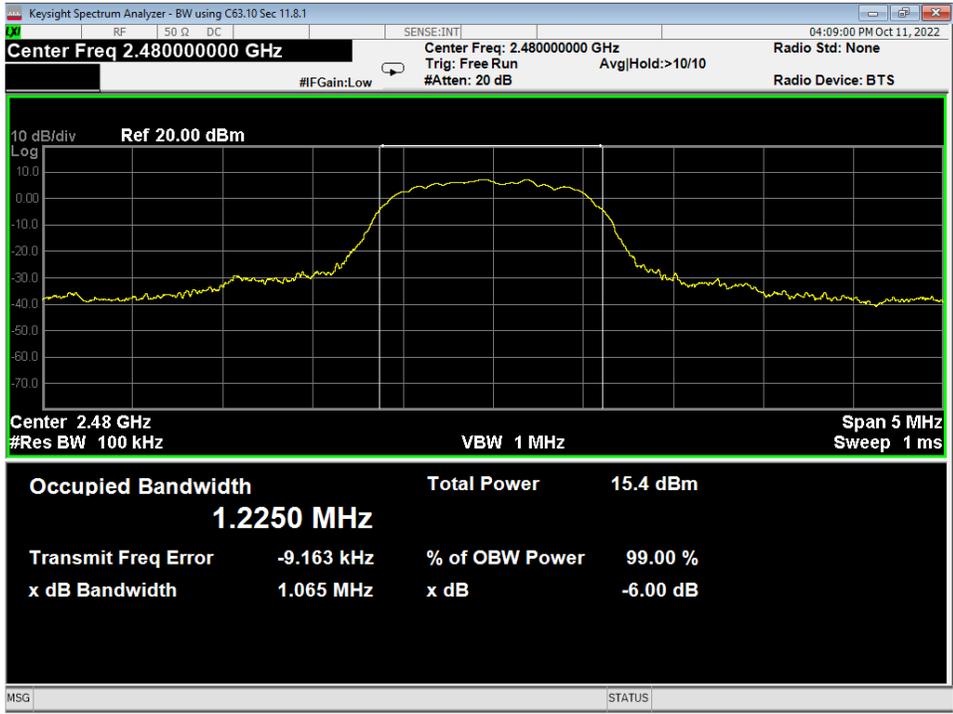
03 Power, High Channel, 2EDR



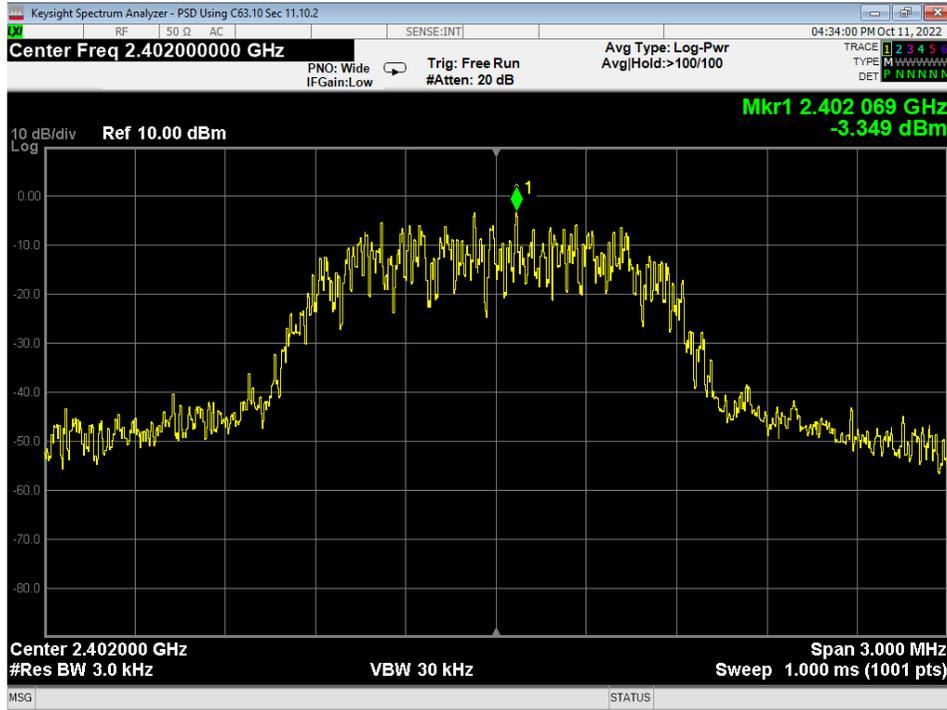
04 6dB Bandwidth, Low Channel, 2EDR



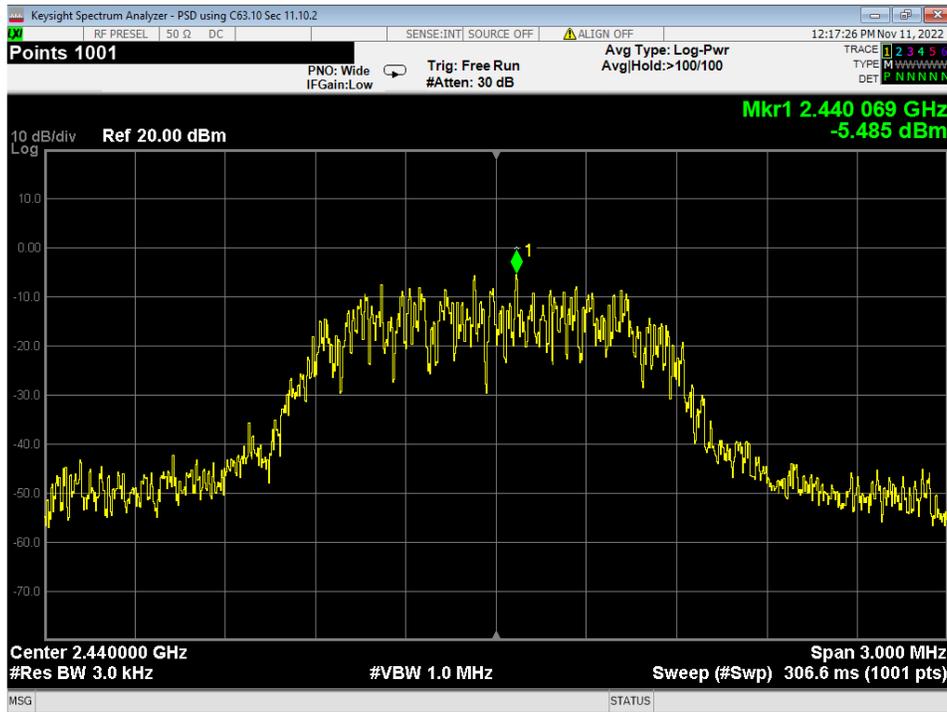
05 6dB Bandwidth, Mid Channel, 2EDR



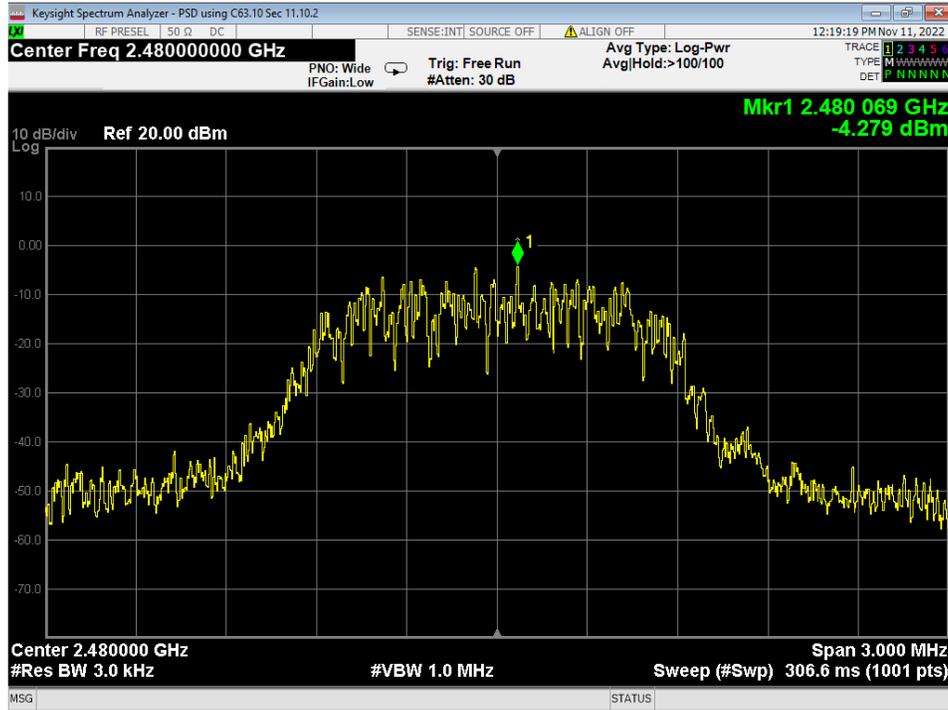
06 6dB Bandwidth, High Channel, 2EDR



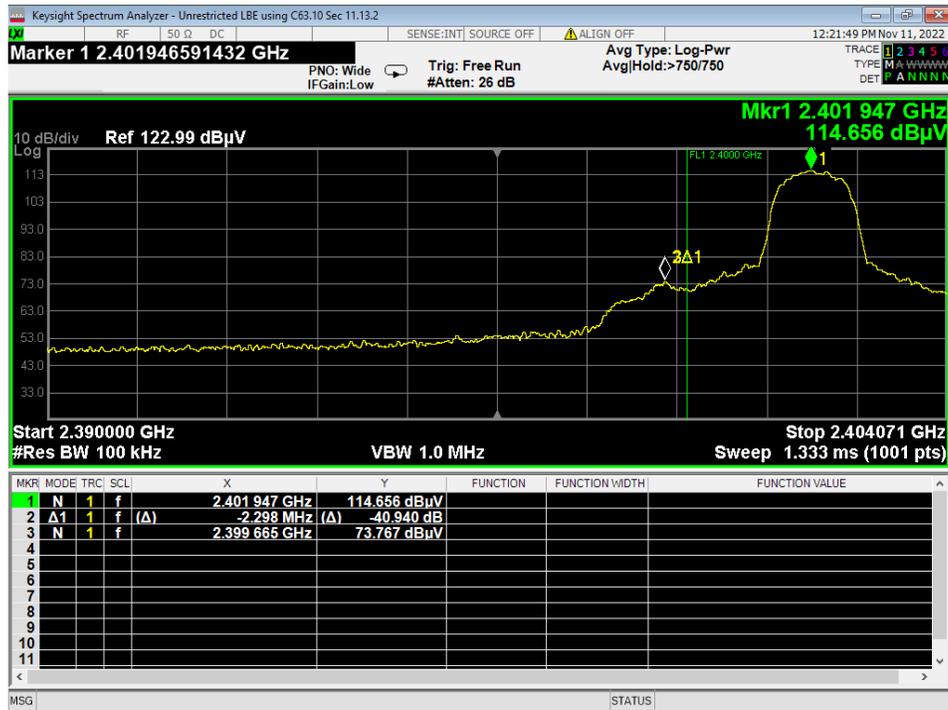
07 PSD, Low Channel, 2EDR



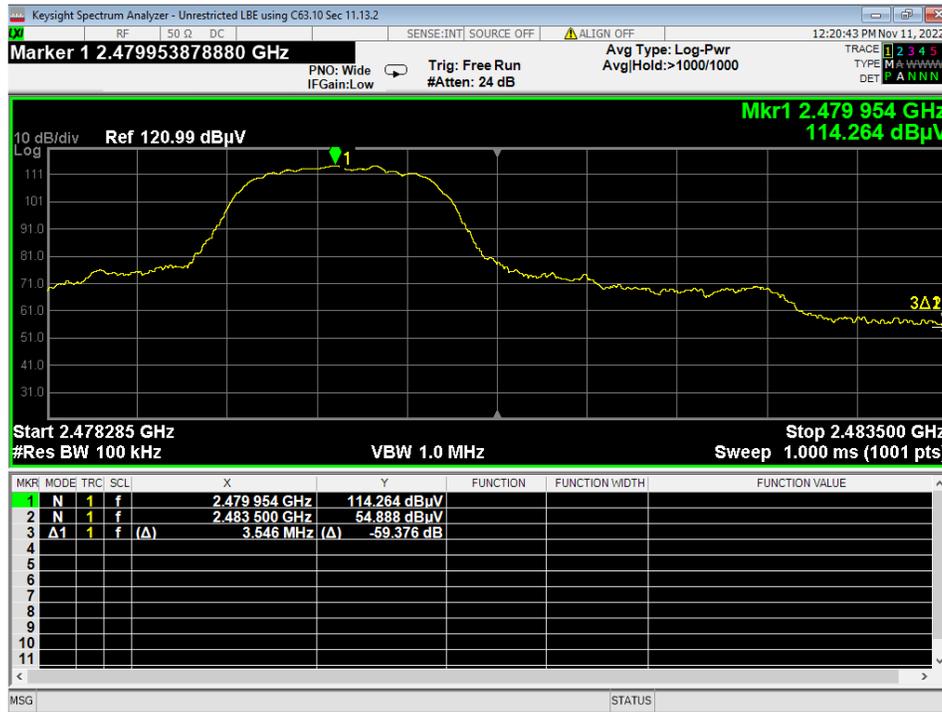
08 PSD, Mid Channel, 2EDR



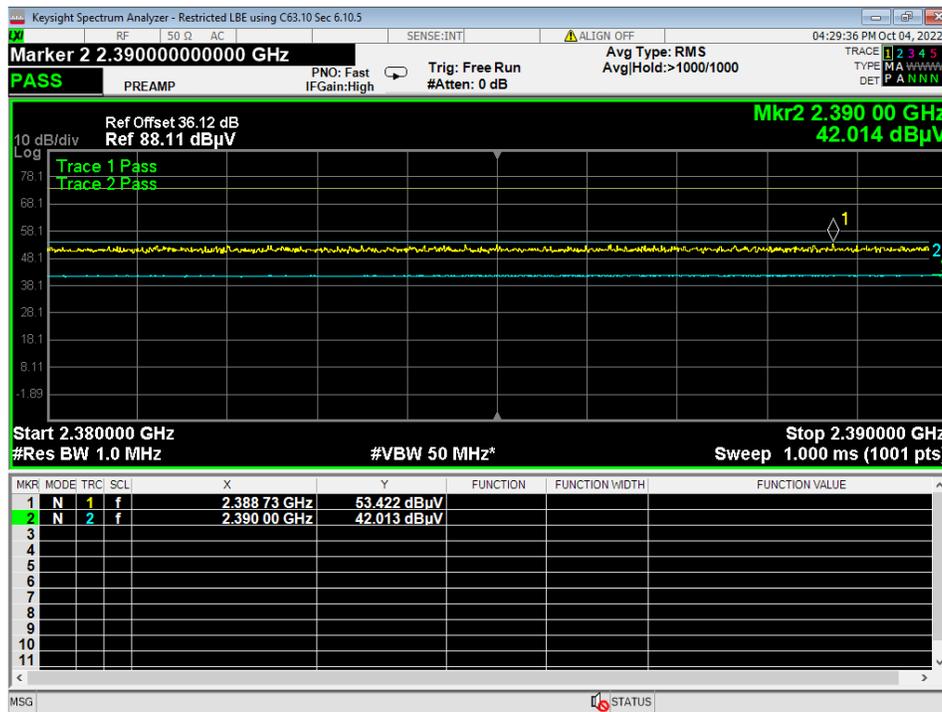
09 PSD, High Channel, 2EDR



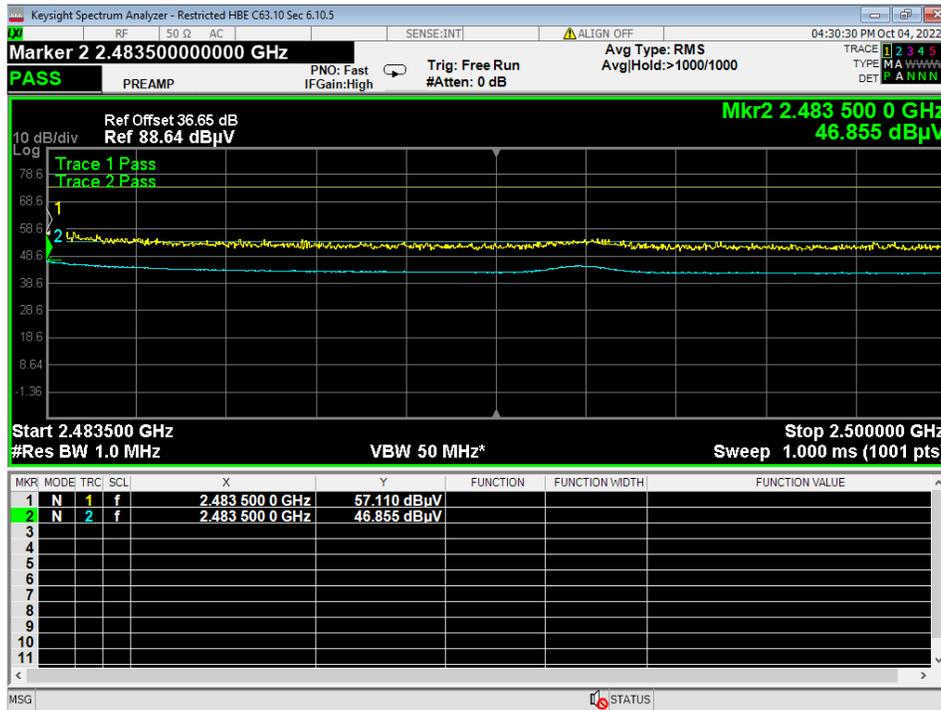
10 Lower Bandedge, Unrestricted, 2EDR



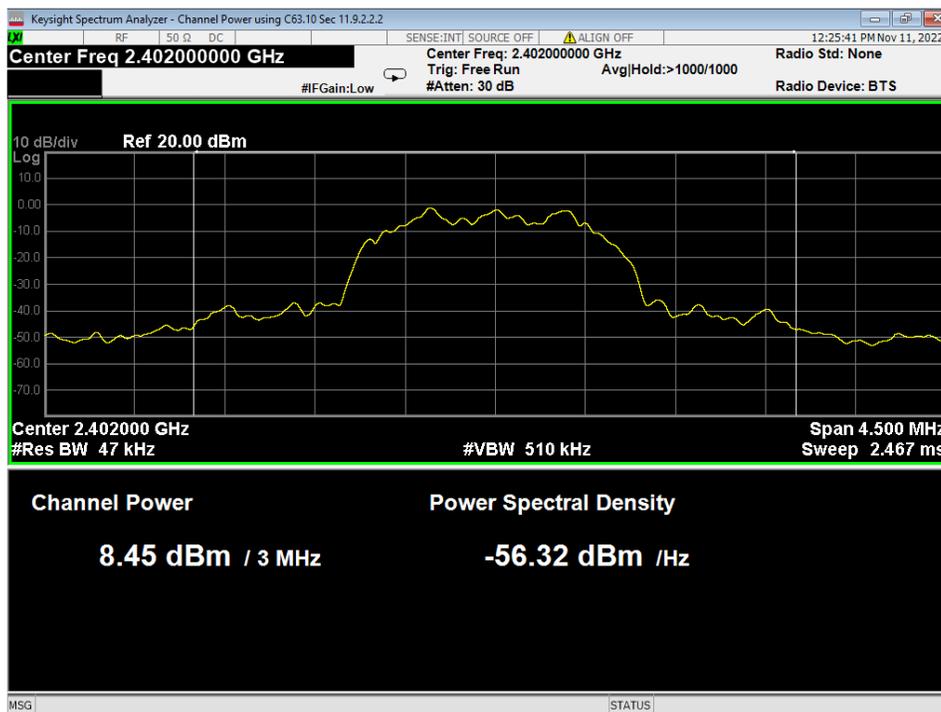
11 Higher Bandedge, Unrestricted, 2EDR



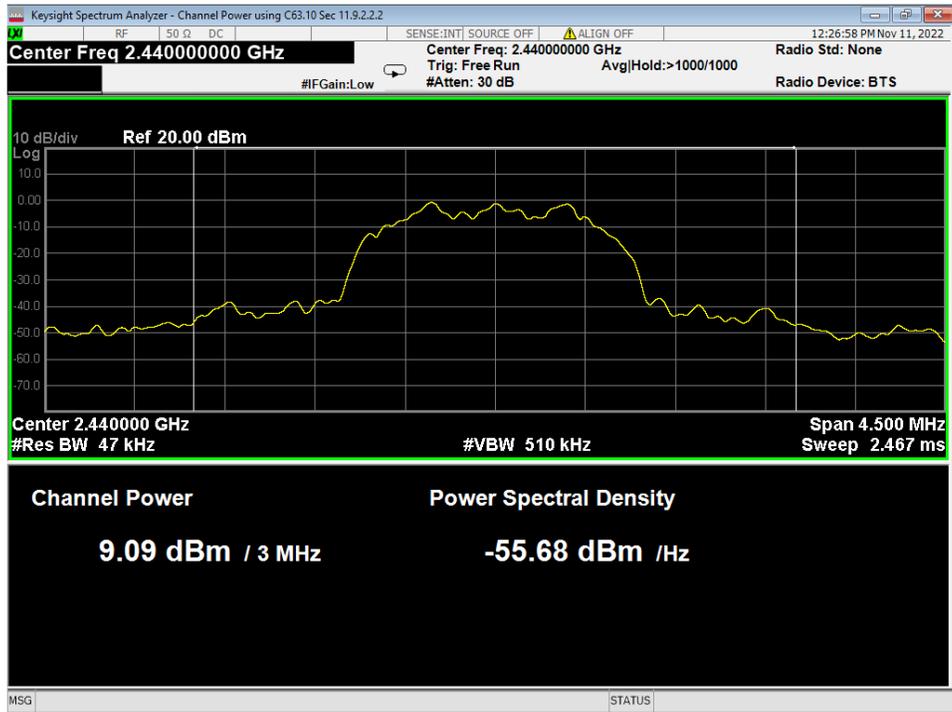
12 Lower Bandedge, Restricted, 2EDR



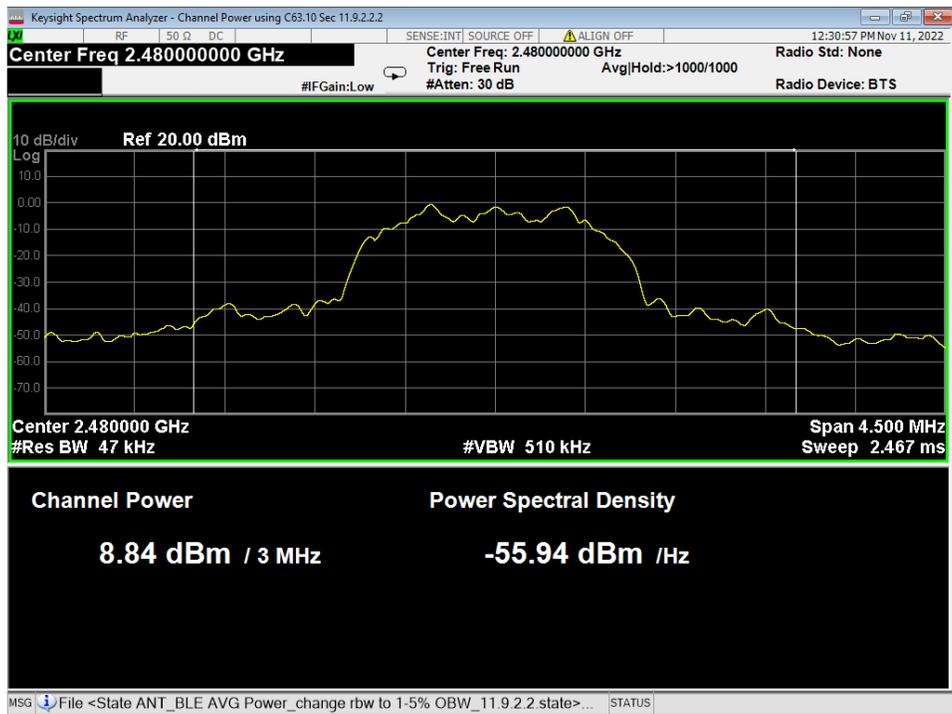
13 Higher Bandedge, Restricted, 2EDR



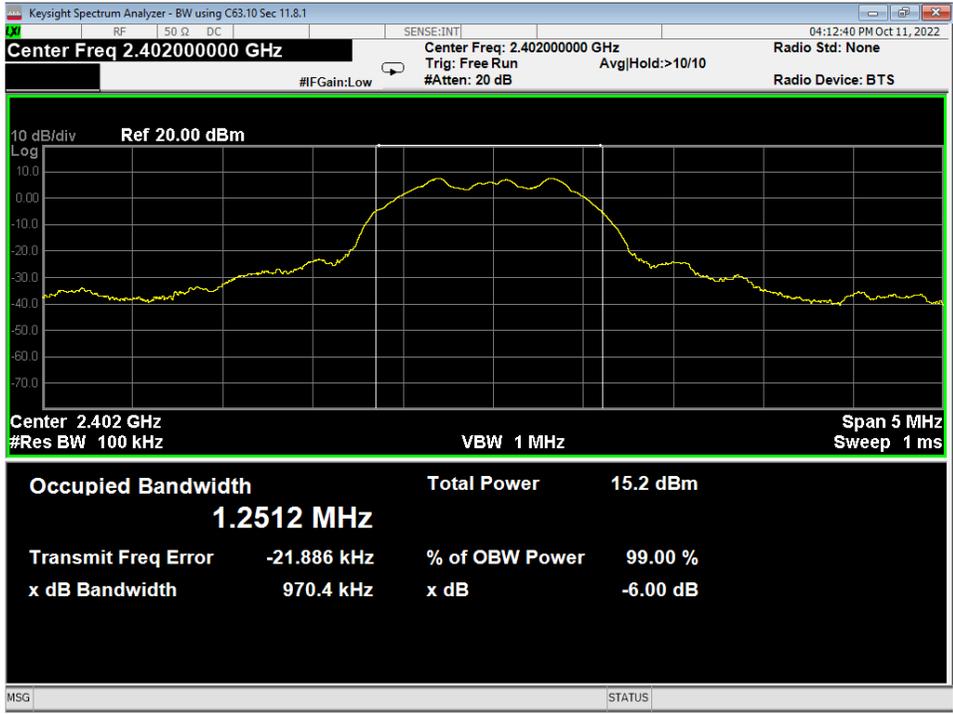
14 Average Power, Low Channel, 3EDR



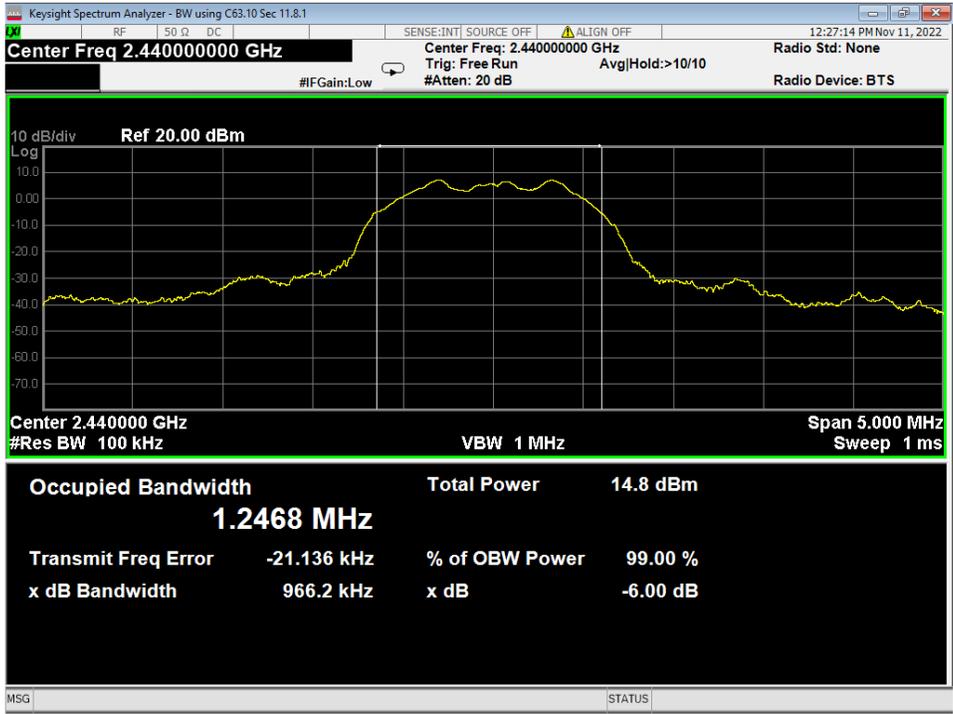
15 Average Power, Mid Channel, 3EDR



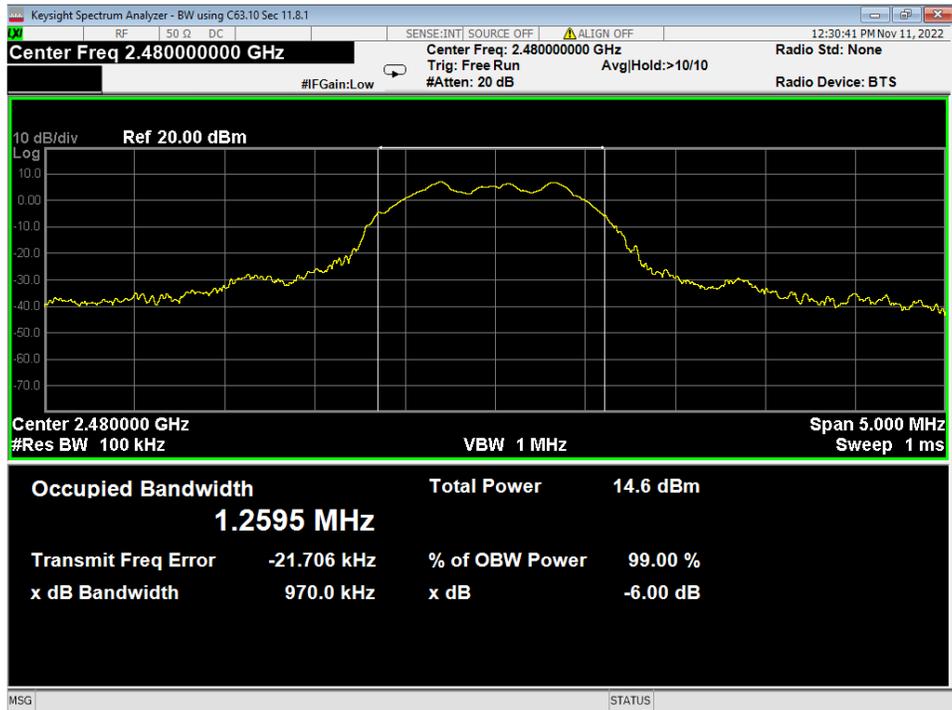
16 Average Power, High Channel, 3EDR



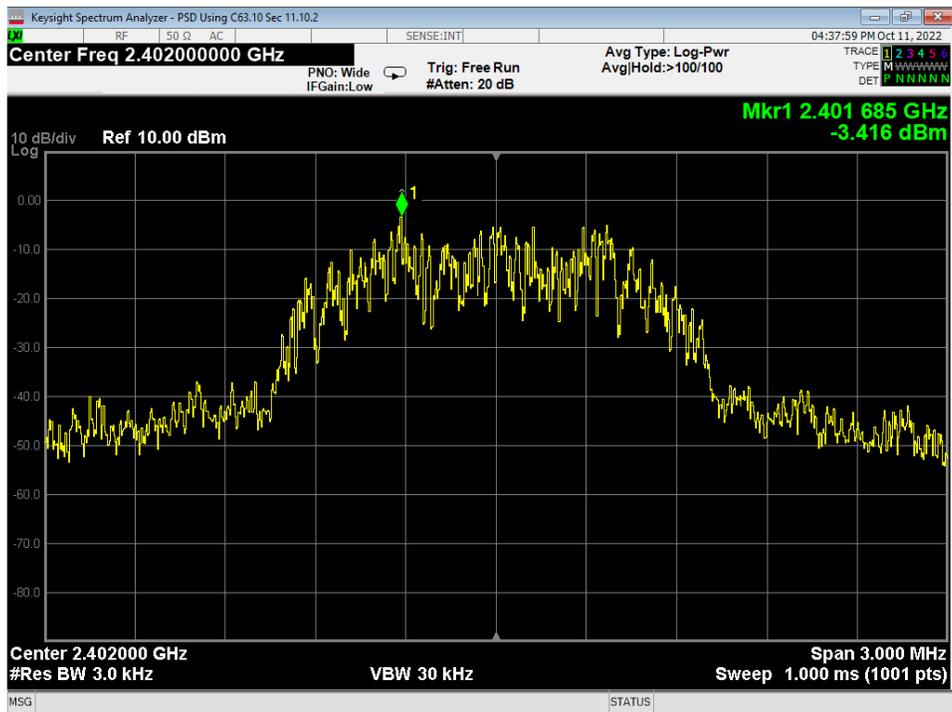
17 6dB Bandwidth, Low Channel, 3EDR



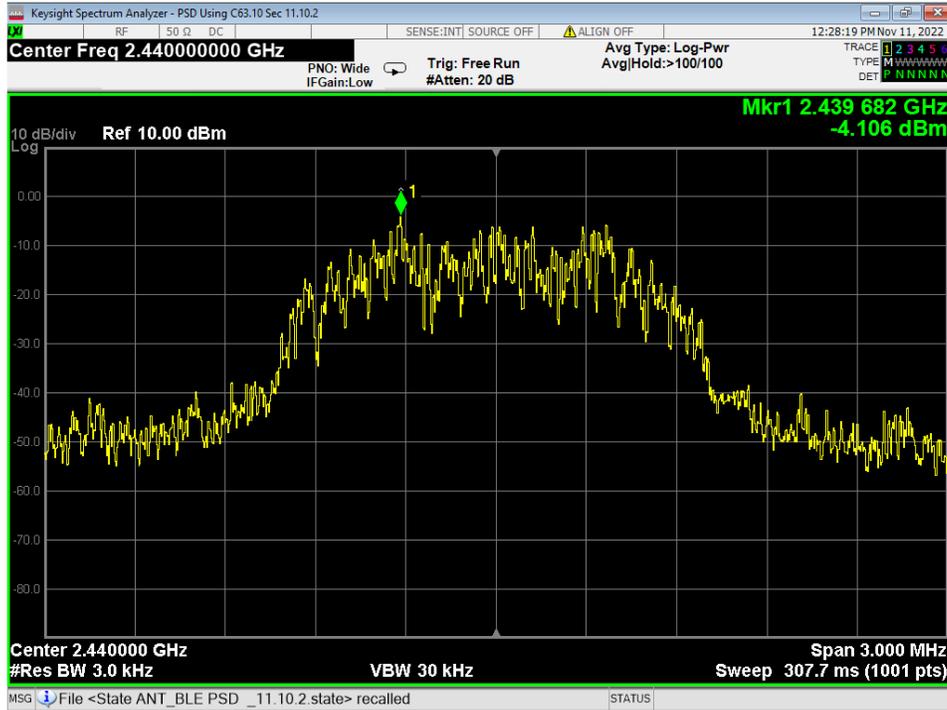
18 6dB Bandwidth, Mid Channel, 3EDR



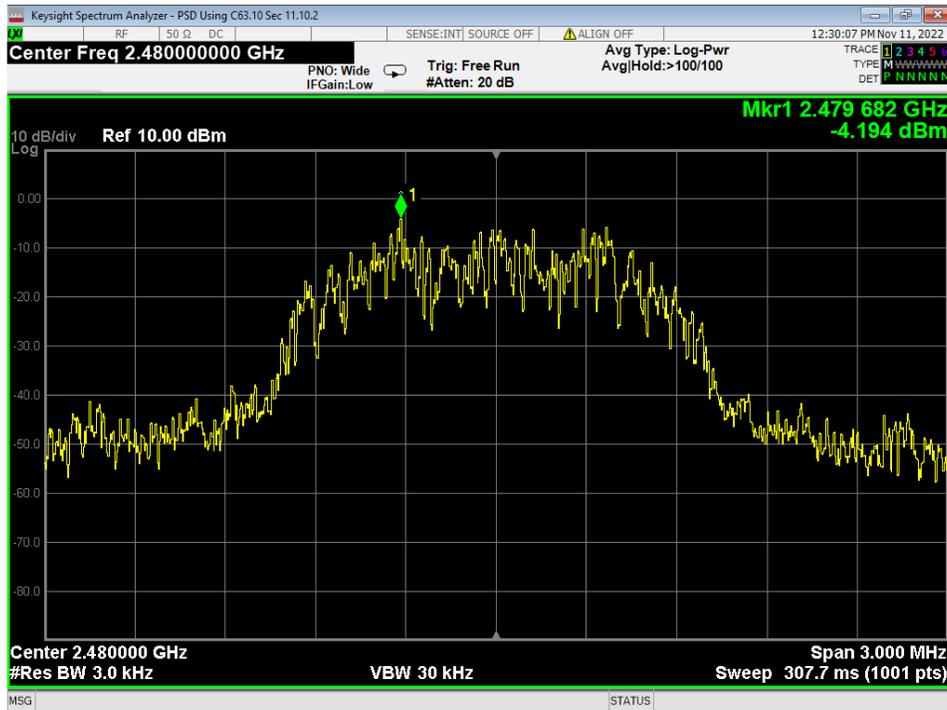
19 6dB Bandwidth, High Channel, 3EDR



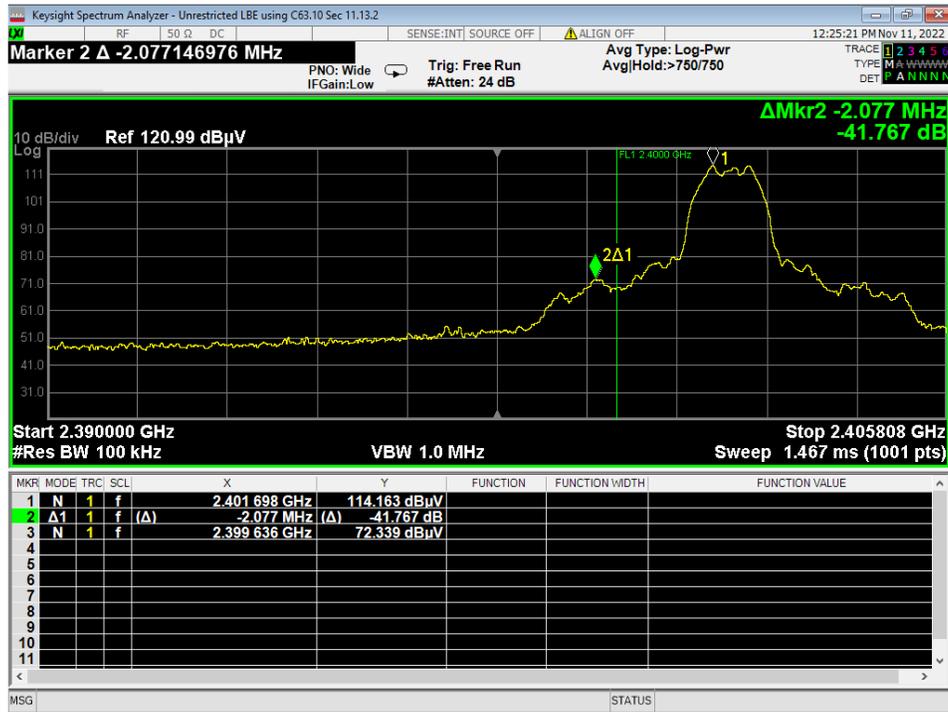
20 PSD, Low Channel, 3EDR



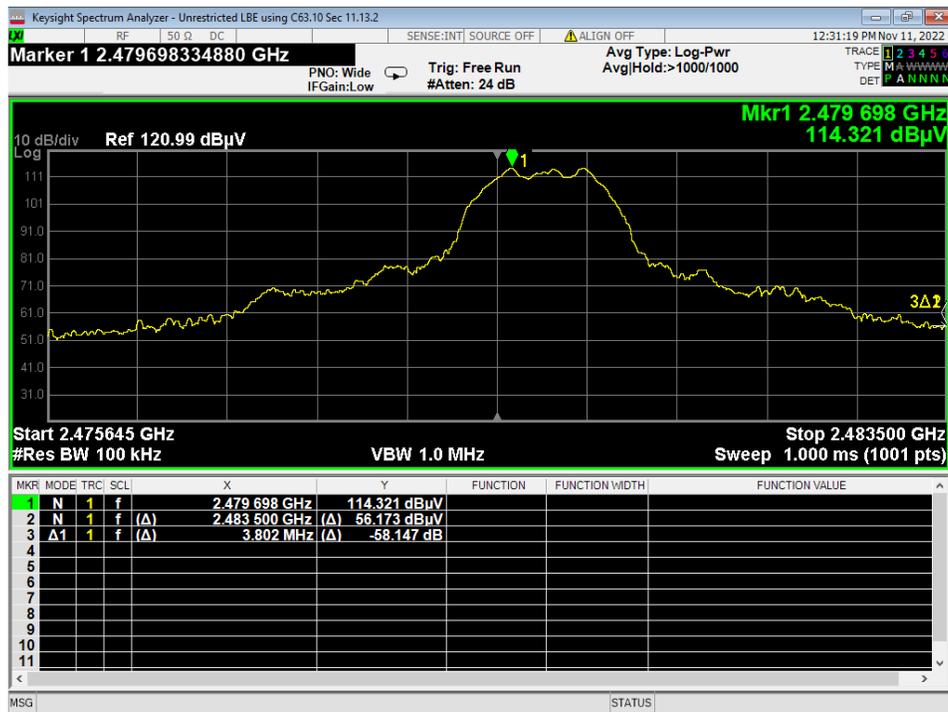
21 PSD, Mid Channel, 3EDR



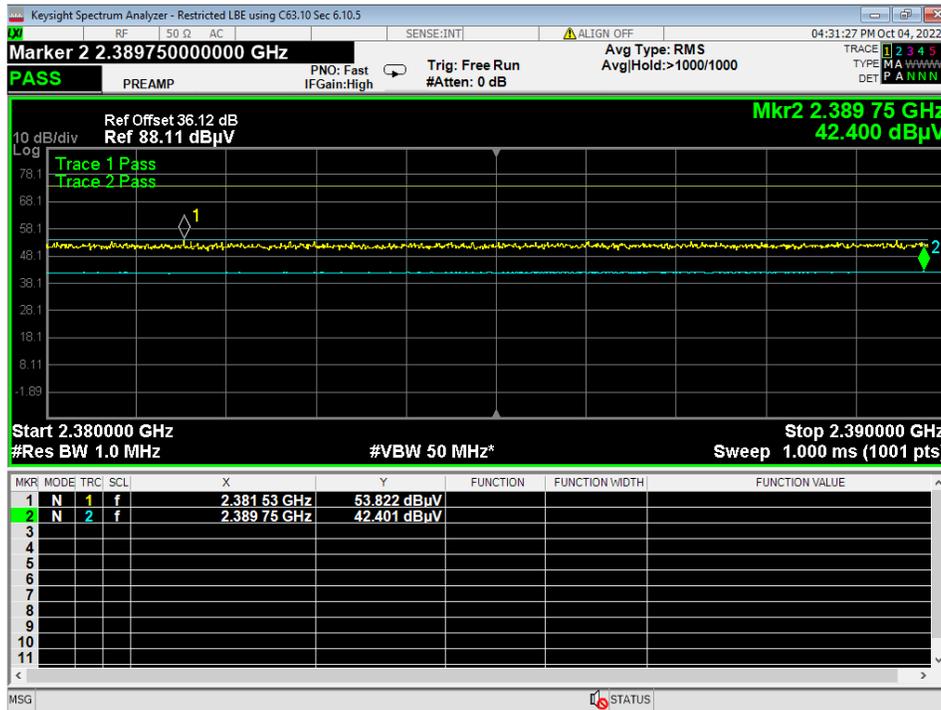
22 PSD, High Channel, 3EDR



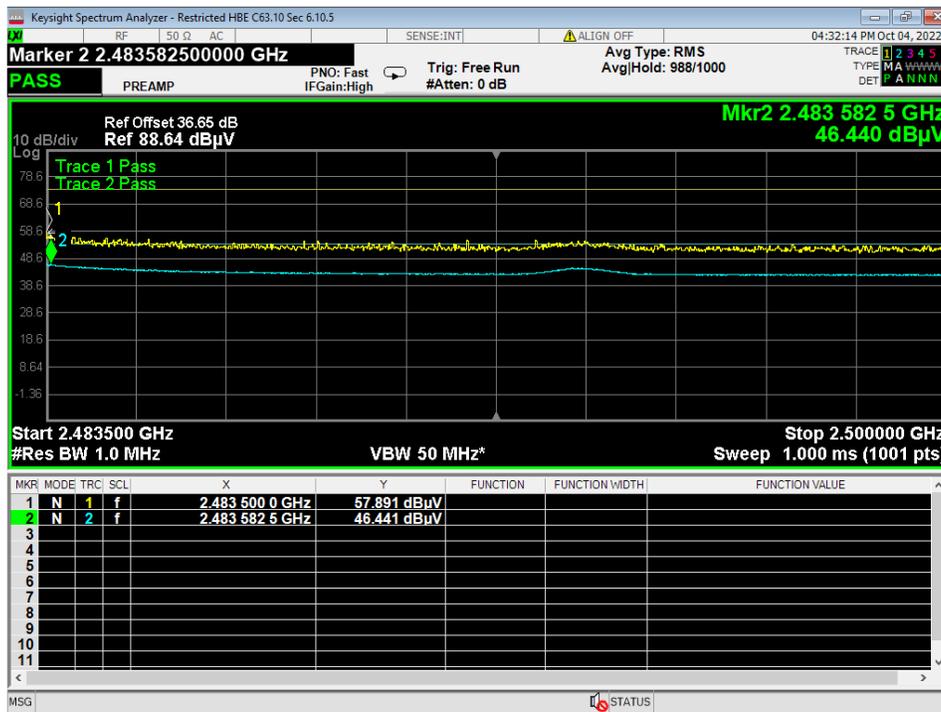
23 Lower Bandedge, Unrestricted, 3EDR



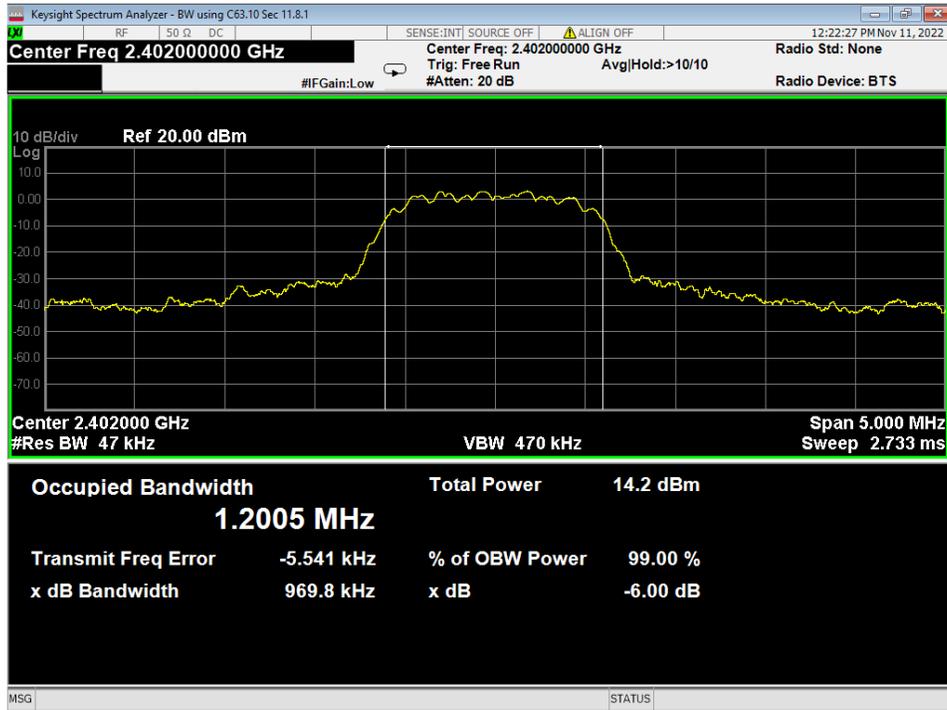
24 Higher Bandedge, Unrestricted, 3EDR



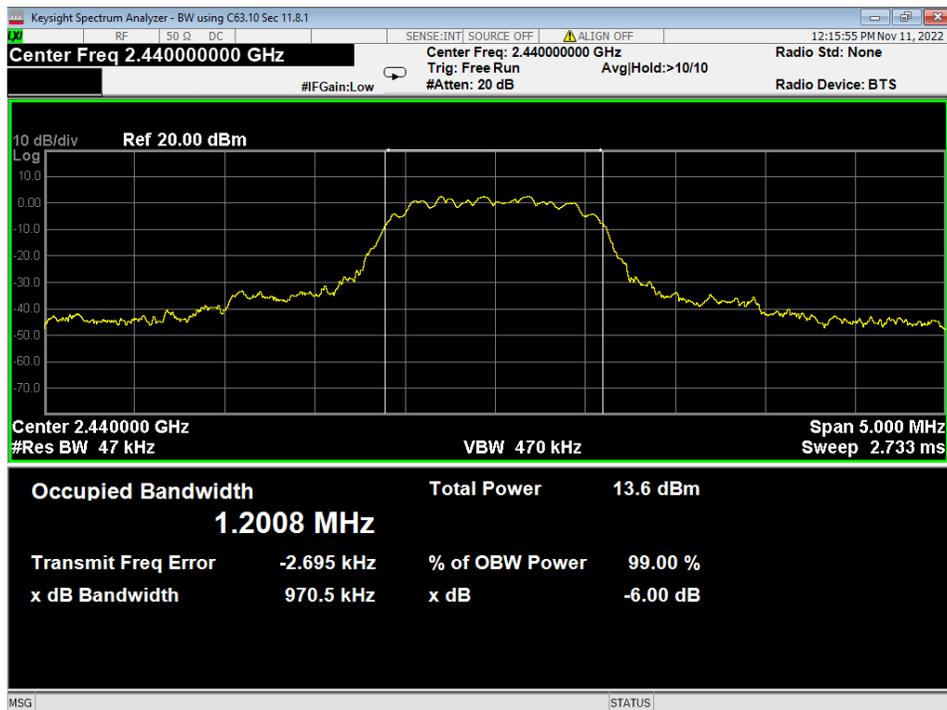
25 Lower Bandedge, Restricted, 3EDR



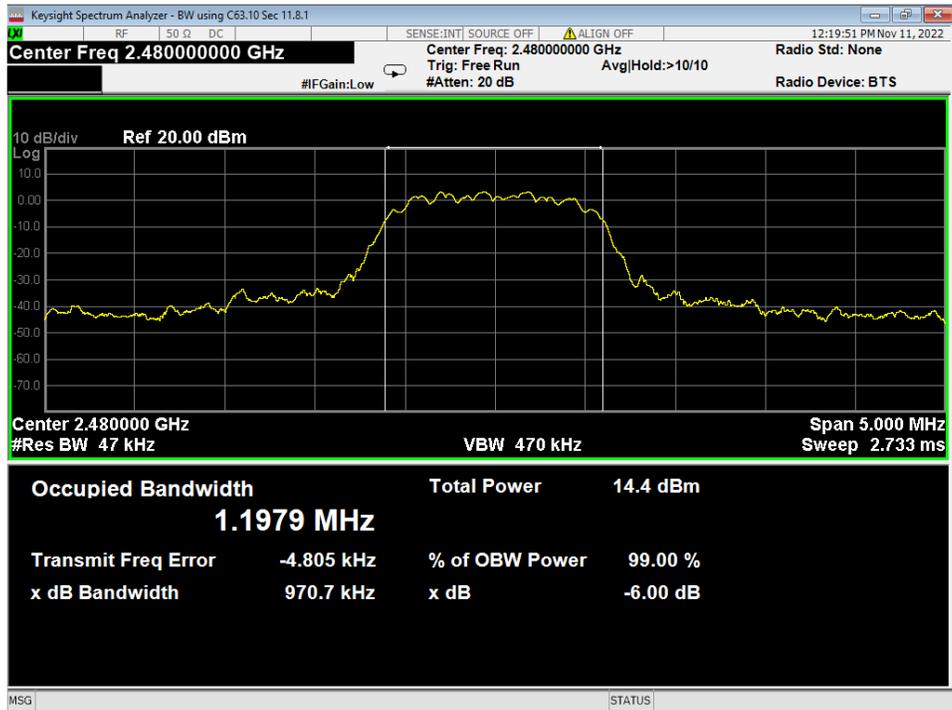
26 Higher Bandedge, Restricted, 3EDR



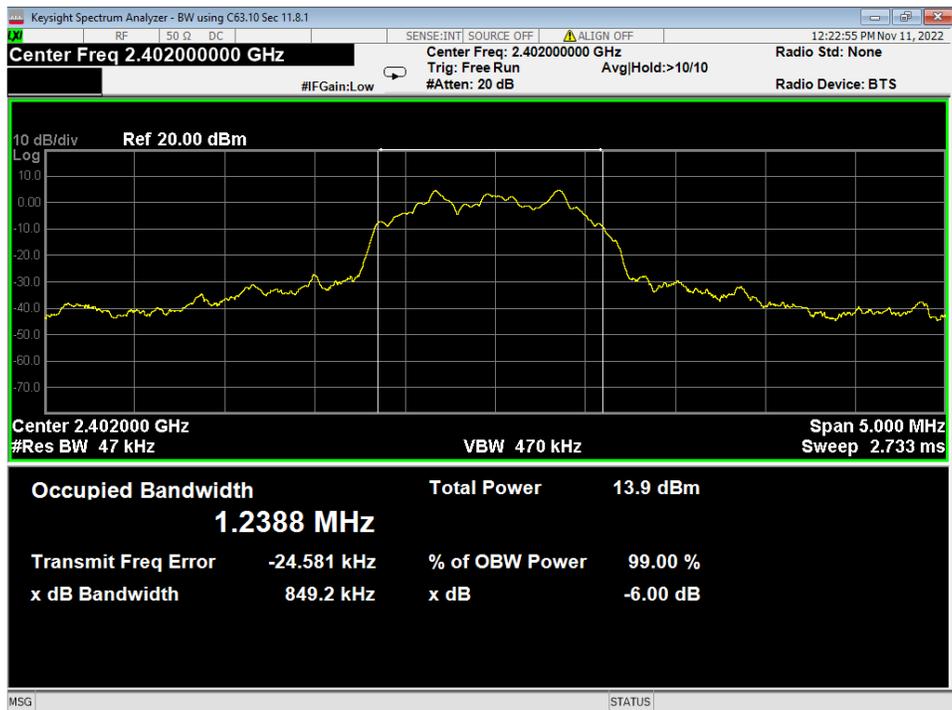
27 Occupied Bandwidth, Low Channel, 2EDR



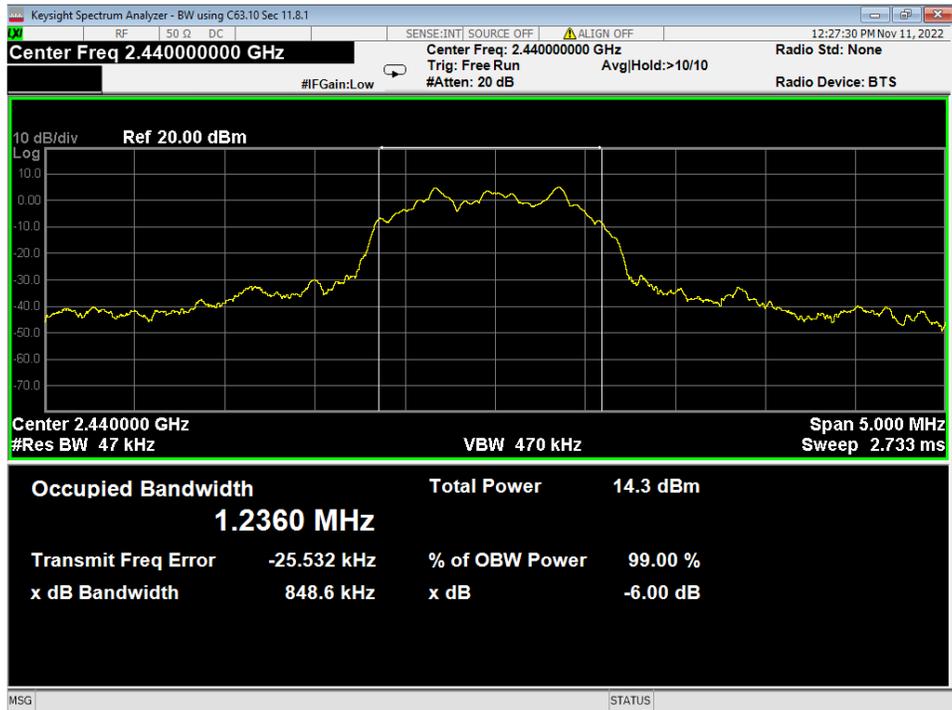
28 Occupied Bandwidth, Mid Channel, 2EDR



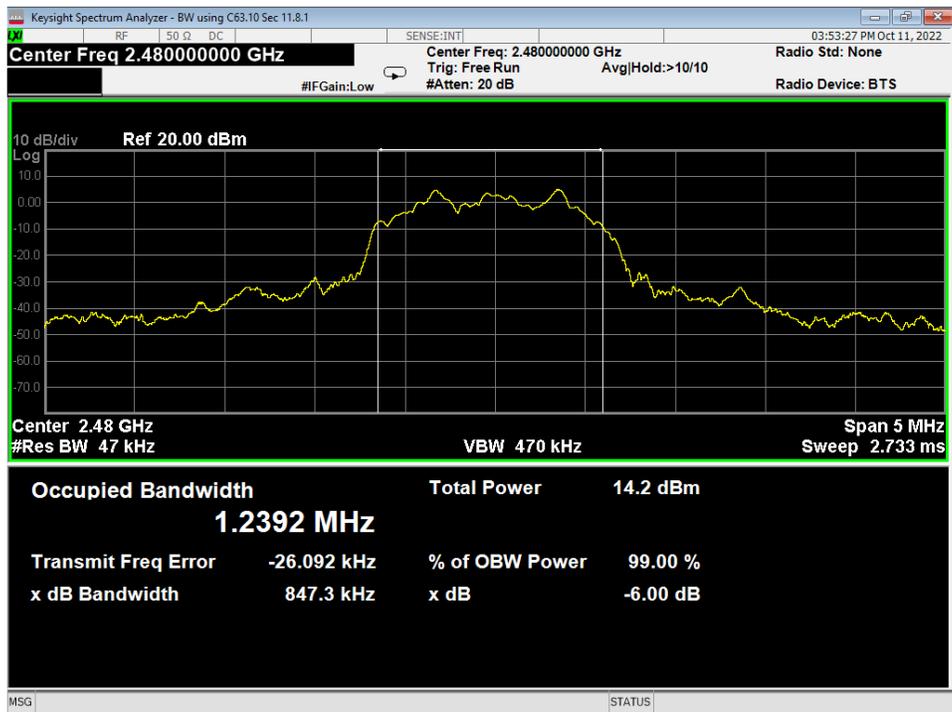
29 Occupied Bandwidth, High Channel, 2EDR



30 Occupied Bandwidth, Low Channel, 3EDR



31 Occupied Bandwidth, Mid Channel, 3EDR



32 Occupied Bandwidth, High Channel, 3EDR



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Prepared for:	Garmin International, Inc.		

REPORT END

## FCC/ISED Test Report

**Prepared for:** Garmin International, Inc.  
**Address:** 1200 E. 151<sup>st</sup> Street  
Olathe, Kansas, 66062, USA  
**Product:** A04452  
**Test Report No:** R20220901-21-E5A

**Approved by:**



**Fox Lane**  
**EMC Test Engineer**

**DATE:** December 7, 2022

**Total Pages:** 136

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Prepared for:	Garmin International, Inc.		

**REVISION PAGE**

<b>Rev. No.</b>	<b>Date</b>	<b>Description</b>
0	18 November 2022	Original – FLane Reviewed By - KVeपुरi Prepared by FLane, GLarsen
A	6 December 2022	Removed Antenna Gain - FL



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## 1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section:

### FCC Part 15.247

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15
- (2) ISED RSS-Gen, Issue 5
- (3) ISED RSS-247, Issue 2

APPLIED STANDARDS AND REGULATIONS		
Standard Section	Test Type	Result
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(b)(3) RSS-247 Issue 2 Section 5.4(d)	Peak output power	Pass
FCC Part 15.247(a)(2) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 5, Section 7.3	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 5, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(e) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 5.5	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass



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## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

#### Summary and Operating Condition:

<b>EUT</b>	A04452
<b>IC</b>	1792A-04452
<b>FCC ID</b>	IPH-04452
<b>EUT Received</b>	3 October 2022
<b>EUT Tested</b>	3 October 2022- 7 November 2022
<b>Serial No.</b>	3426283485 (Radiated Measurements) 3426283465 (Conducted Measurements)
<b>Operating Band</b>	2400 – 2483.5 MHz
<b>Device Type</b>	<input type="checkbox"/> GMSK <input type="checkbox"/> GFSK <input type="checkbox"/> BT BR <input type="checkbox"/> BT EDR 2MB <input type="checkbox"/> BT EDR 3MB <input checked="" type="checkbox"/> 802.11x
<b>Power Supply / Voltage</b>	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: AQ27A-59CFA GPN: 362-00118-00 (Representative Power Supply)

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

### 2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

Data Rates:

Modulation	Low/High Data rate
802.11b	1MB/11MB
802.11g	6MB/54MB
802.11n	MCS0/MCS7

For 802.11x Transmissions:

Channel	Frequency
Low	2412 MHz
Mid	2437 MHz
High	2462 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

### 2.3 DESCRIPTION OF SUPPORT UNITS

None

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### 3.0 LABORATORY AND GENERAL TEST DESCRIPTION

#### 3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)  
 4740 Discovery Drive  
 Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of  $35 \pm 4\%$   
 Temperature of  $22 \pm 3^\circ$  Celsius



#### 3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Testing and Report
2	Nic Johnson	Technical Manager	Review and Editing
2	Blake Winter	Test Engineer	Testing
3	Grace Larsen	Test Engineer	Testing and Report
4	Ethan Schmidt	Test Technician	Testing

**Notes:**

All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.



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### 3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
EMCO Horn Antenna	3115	6416	July 28, 2021	July 28, 2022
EMCO Horn Antenna***	3116	2576	March 9, 2020	March 9, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preampfier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Rohde & Schwarz Preampfier**	TS-PR18	3545700803	August 22, 2022	August 22, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber***	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preampfier to antenna)*	MFR-57500	01-07-002	March 21, 2022	March 21, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

\*Internal Characterization  
 \*\*2 Year Cal Cycle  
 \*\*\*3 Year Cal Cycle

**Notes:**

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

### 3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMENTS

Measurement type presented in this report (Please see the checked box below):

#### Conducted

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

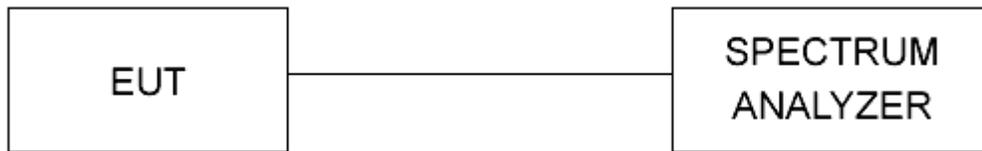


Figure 1 - Bandwidth Measurements Test Setup

#### Radiated

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

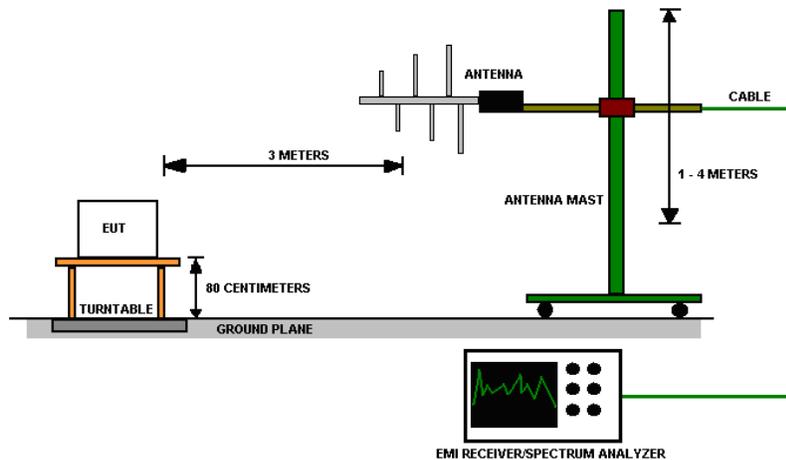


Figure 2 - Radiated Emissions Test Setup



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#### 4.0 RESULTS

DTS Radio Measurements Low Data Rate							
CHANNEL	Transmitter	Occupied Bandwidth (MHz)	6 dB Bandwidth (MHz)	AVERAGE OUTPUT POWER (dBm)	AVERAGE OUTPUT POWER (mW)	PSD (dBm)	RESULT
Low	802.11 b	15.05	14.95	15.340	34.198	1.352	PASS
Mid	802.11 b	15.07	14.99	17.680	58.614	1.447	PASS
High	802.11 b	14.94	14.86	13.930	24.717	-0.048	PASS
Low	802.11 g	16.68	16.53	9.940	9.863	-14.729	PASS
Mid	802.11 g	16.83	16.55	14.630	29.040	-11.121	PASS
High	802.11 g	16.74	16.53	8.110	6.471	-16.973	PASS
Low	802.11 n	17.524	17.528	9.99	9.977	-15.607	PASS
Mid	802.11 n	17.582	17.547	14.29	26.853	-11.265	PASS
High	802.11 n	17.523	17.534	7.53	5.662	-18.353	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit =500 kHz				Output Power Limit = 30 dBm; PSD Limit = 8 dBm			
Unrestricted Band-Edge Low Data Rate							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamental (dBuV)	Delta (dB)	Min Delta (dB)	Result
Low	802.11 b	2400.00	76.57	112.68	36.11	30.00	PASS
Low	802.11 g	2400.00	67.33	103.60	36.27	30.00	PASS
Low	802.11 n	2400.00	66.96	103.29	36.32	30.00	PASS
High	802.11 b	2483.50	55.52	110.94	55.42	30.00	PASS
High	802.11 g	2483.50	54.90	100.81	45.91	30.00	PASS
High	802.11 n	2483.50	58.34	100.50	42.17	30.00	PASS
Radiated Peak Restricted Band-Edge Low Data Rate							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	802.11 b	2390.00	55.57	Peak	73.98	18.41	PASS
Low	802.11 g	2390.00	60.21	Peak	73.98	13.77	PASS
Low	802.11 n	2390.00	63.77	Peak	73.98	10.21	PASS
High	802.11 b	2483.50	53.72	Peak	73.98	20.26	PASS
High	802.11 g	2483.50	61.97	Peak	73.98	12.01	PASS
High	802.11 n	2483.50	62.50	Peak	73.98	11.48	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							



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**Radiated Average Restricted Band-Edge Low Data Rate**

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	802.11 b	2390.00	44.61	Average	53.98	9.37	PASS
Low	802.11 g	2390.00	46.87	Average	53.98	7.11	PASS
Low	802.11 n	2390.00	48.25	Average	53.98	5.74	PASS
High	802.11 b	2483.50	42.16	Average	53.98	11.82	PASS
High	802.11 g	2483.50	47.27	Average	53.98	6.71	PASS
High	802.11 n	2483.50	49.37	Average	53.98	4.61	PASS

\*Limit shown is the average limit taken from FCC Part 15.209



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DTS Radio Measurements High Data Rate							
CHANNEL	Transmitter	Occupied Bandwidth (MHz)	6 dB Bandwidth (MHz)	AVERAGE OUTPUT POWER (dBm)	AVERAGE OUTPUT POWER (mW)	PSD (dBm)	RESULT
Low	802.11 b	14.69	14.66	14.910	30.974	-8.286	PASS
Mid	802.11 b	14.69	14.66	17.780	59.979	-7.592	PASS
High	802.11 b	14.65	14.65	13.770	23.823	-9.541	PASS
Low	802.11 g	16.56	16.41	10.010	10.023	-13.711	PASS
Mid	802.11 g	16.61	16.41	12.950	19.724	-11.076	PASS
High	802.11 g	16.56	16.40	8.660	7.345	-16.151	PASS
Low	802.11 n	17.50	17.46	10.140	10.328	-15.421	PASS
Mid	802.11 n	17.50	17.48	11.140	13.002	-14.519	PASS
High	802.11 n	17.47	17.48	8.370	6.871	-17.486	PASS

Occupied Bandwidth = N/A; 6 dB Bandwidth Limit =500 kHz      Output Power Limit = 30 dBm; PSD Limit = 8 dBm

Unrestricted Band-Edge High Data Rate							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamenta l (dBuV)	Delta (dB)	Min Delta (dB)	Result
Low	802.11 b	2390.00	75.50	112.39	36.89	30.00	PASS
Low	802.11 g	2390.00	67.29	104.48	37.20	30.00	PASS
Low	802.11 n	2390.00	67.87	105.15	37.28	30.00	PASS
High	802.11 b	2483.50	54.13	110.82	56.69	30.00	PASS
High	802.11 g	2483.50	55.93	102.66	46.73	30.00	PASS
High	802.11 n	2483.50	56.40	102.77	46.36	30.00	PASS

Radiated Peak Restricted Band-Edge High Data Rate							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	802.11 b	2390.00	55.69	Peak	73.98	18.29	PASS
Low	802.11 g	2390.00	64.83	Peak	73.98	9.15	PASS
Low	802.11 n	2390.00	62.62	Peak	73.98	11.36	PASS
High	802.11 b	2483.50	59.95	Peak	73.98	14.03	PASS
High	802.11 g	2483.50	66.39	Peak	73.98	7.59	PASS
High	802.11 n	2483.50	65.92	Peak	73.98	8.06	PASS

\*Limit shown is the peak limit taken from FCC Part 15.209



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Radiated Average Restricted Band-Edge High Data Rate							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	802.11 b	2390.00	44.54	Average	53.98	9.44	PASS
Low	802.11 g	2390.00	49.29	Average	53.98	4.69	PASS
Low	802.11 n	2390.00	48.80	Average	53.98	5.18	PASS
High	802.11 b	2483.50	48.64	Average	53.98	5.34	PASS
<b>High</b>	<b>802.11 g</b>	<b>2483.50</b>	<b>50.35</b>	<b>Average</b>	<b>53.98</b>	<b>3.63</b>	<b>PASS</b>
High	802.11 n	2483.50	49.46	Average	53.98	4.52	PASS

\*Limit shown is the average limit taken from FCC Part 15.209



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#### 4.1 OUTPUT POWER

**Test Method:** Power measurements were performed using ANSI C63.10, Section 11.9.2.2.2.

**Limits of power measurements:**

**For FCC Part 15.247 Device:**

The maximum allowed output power is 30 dBm.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the output power plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables in section 4.0.



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## 4.2 BANDWIDTH

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of bandwidth measurements:**

**For FCC Part 15.247 Device:**

The 99% occupied bandwidth is for informational purpose only. The 6dB bandwidth of the signal must be greater than 500 kHz.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the bandwidth plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables in section 4.0.



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### 4.3 DUTY CYCLE

**Test Method:**

All Modulations/Transmitters in this report had a duty cycle of >98%

#### 4.4 RADIATED EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.5, 6.6

**Limits for radiated emissions measurements:**

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ( $\mu\text{V/m}$ )	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

**NOTE:**

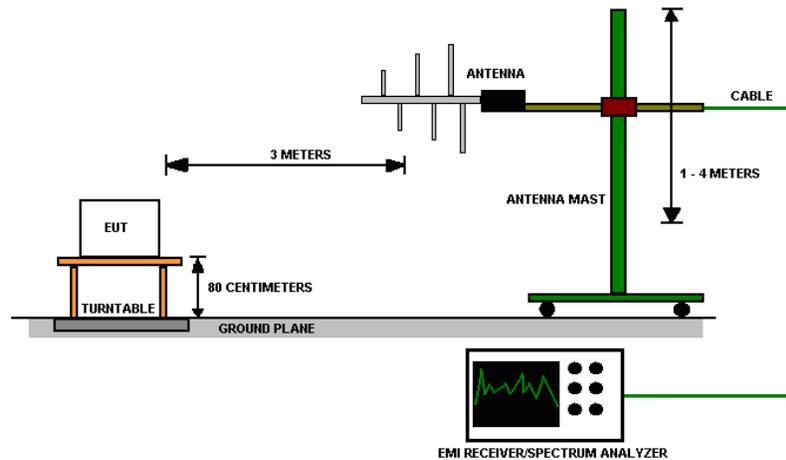
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) =  $20 * \log * \text{Emission level } (\mu\text{V/m})$ .
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.



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**Test procedures:**

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise, the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

**Test setup:**

**Figure 3 - Radiated Emissions Test Setup**
**NOTE:**

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

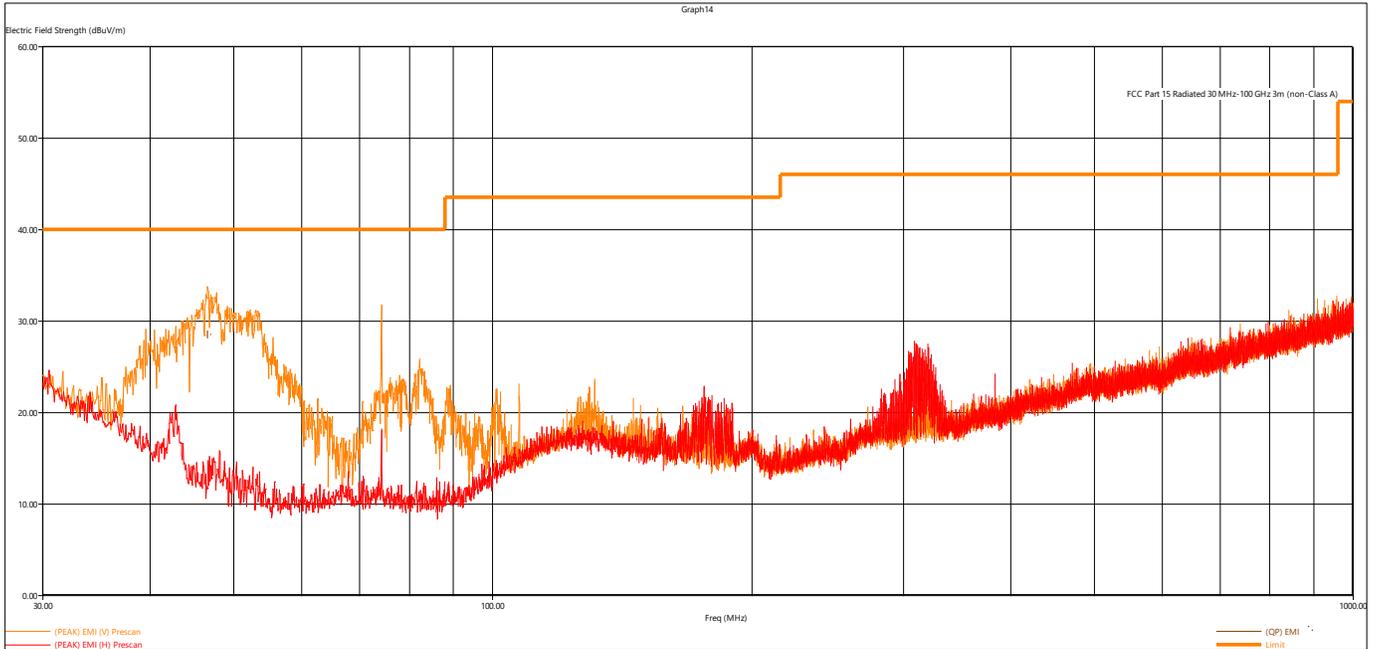
**Deviations from test standard:**

No deviation.

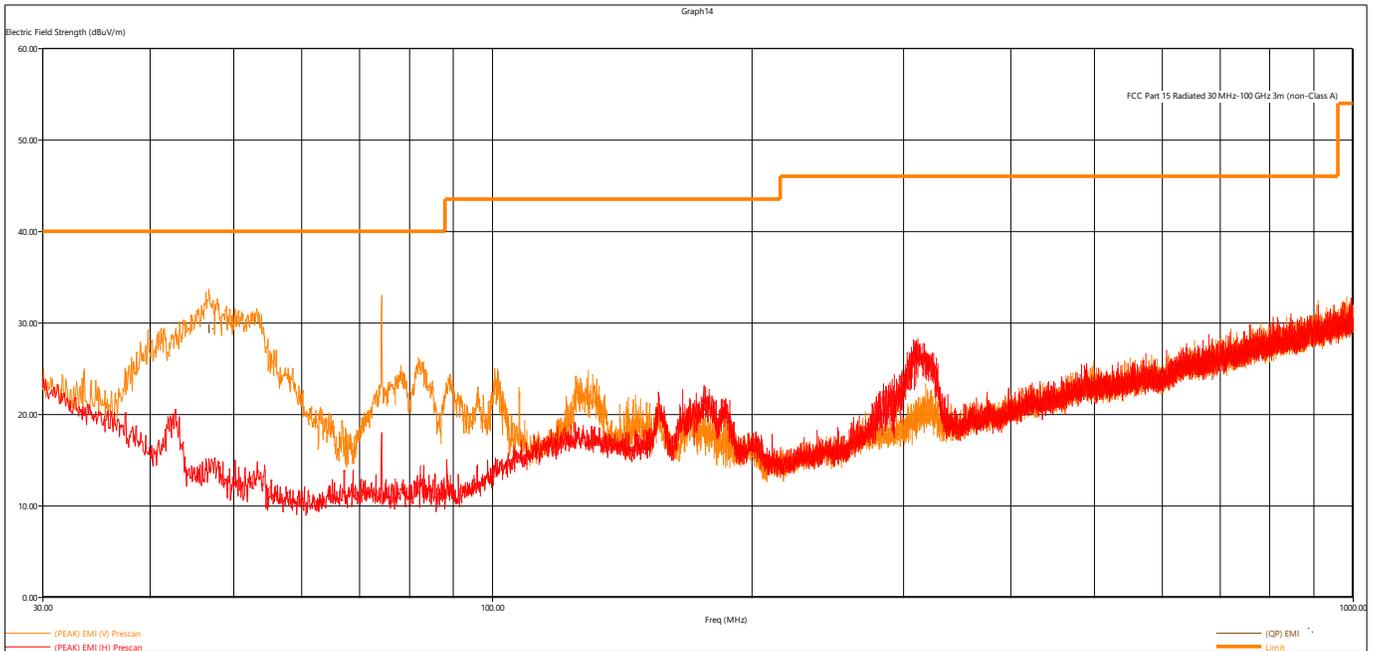
**EUT operating conditions**

Details can be found in section 2.1 of this report.

**Test results:**



**Figure 4 - Radiated Emissions Plot, Receive**



**Figure 5 - Radiated Emissions Plot, 802.11b 1MB**

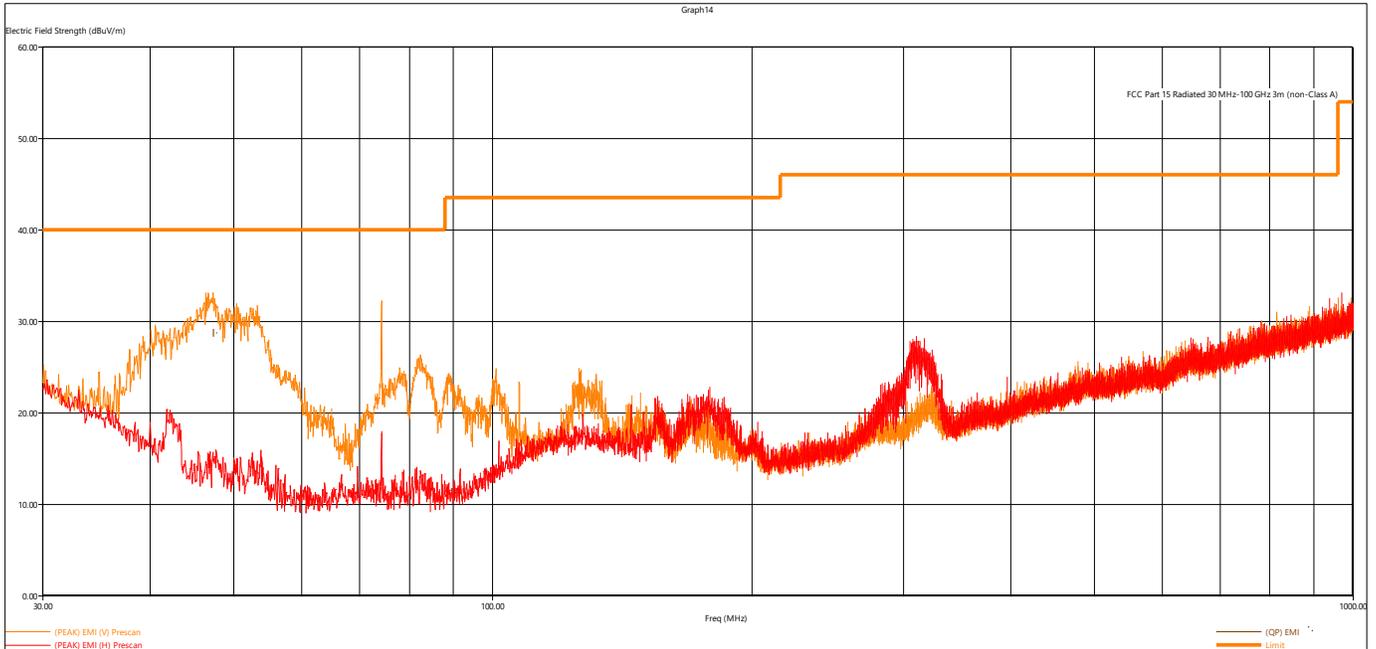


Figure 6 - Radiated Emissions Plot, 802.11b 11MB

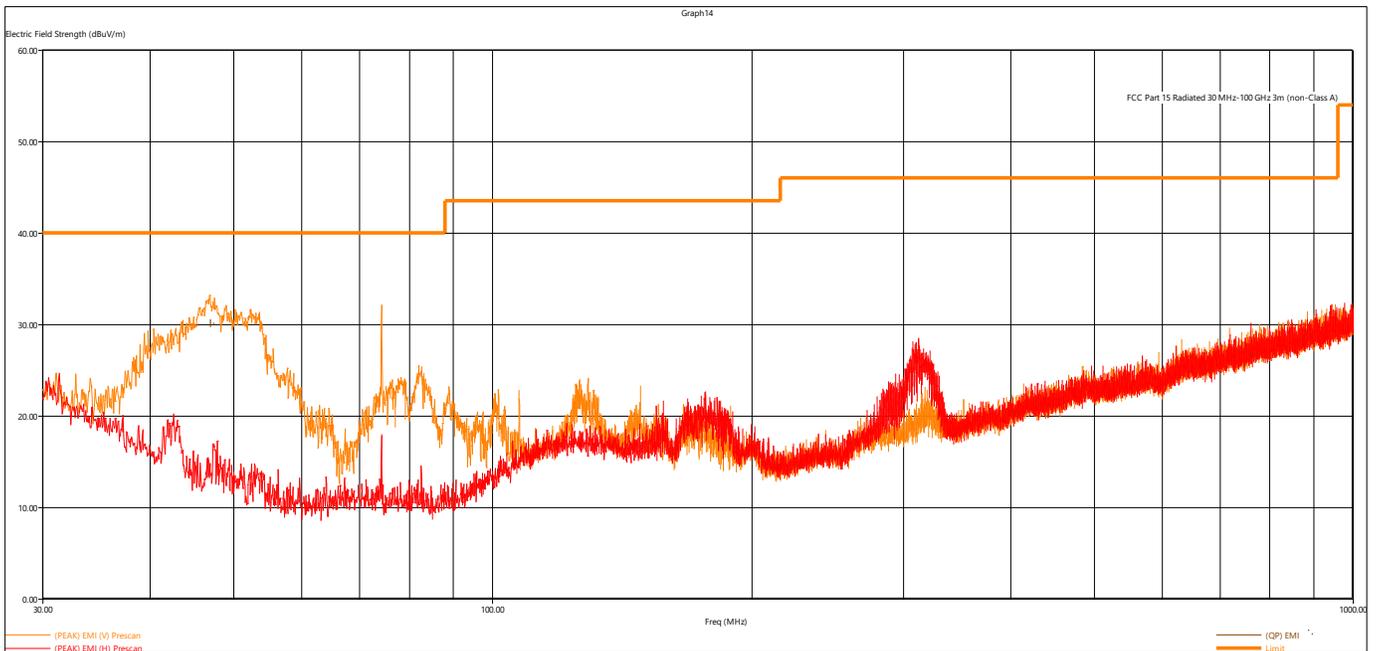


Figure 7 - Radiated Emissions Plot, 802.11g 6MB

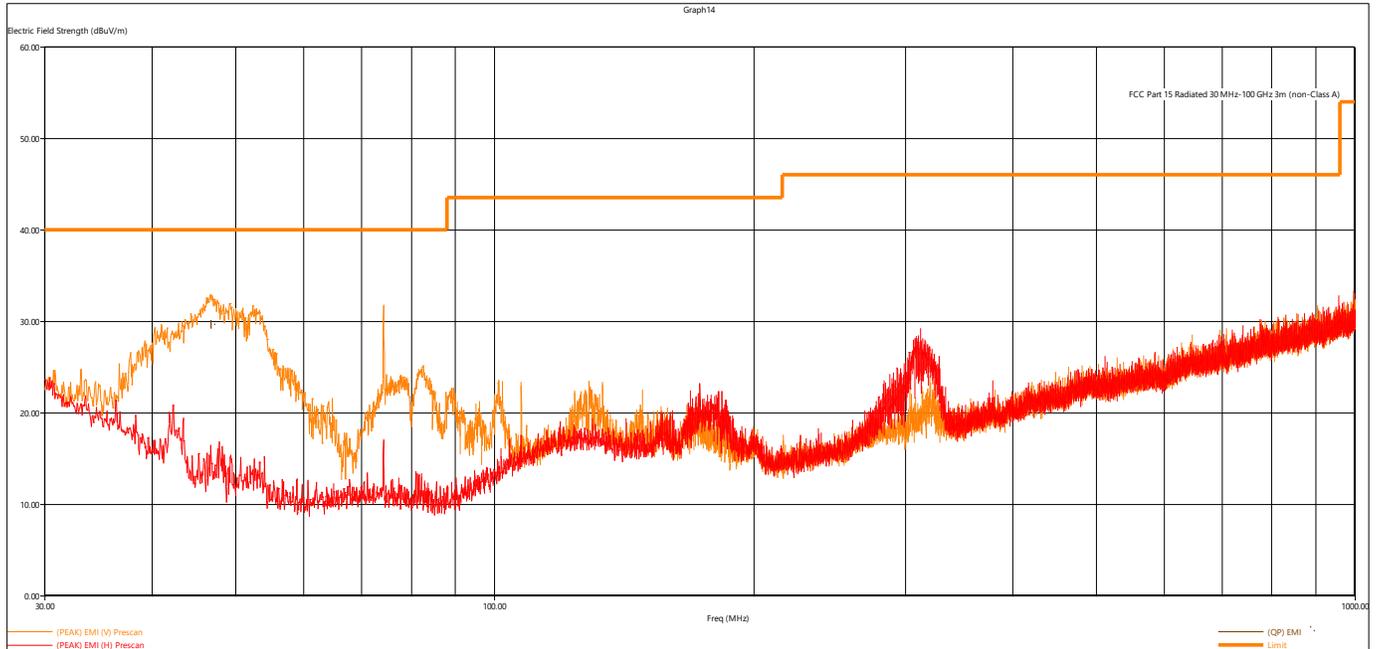


Figure 8 - Radiated Emissions Plot, 802.11g 54MB

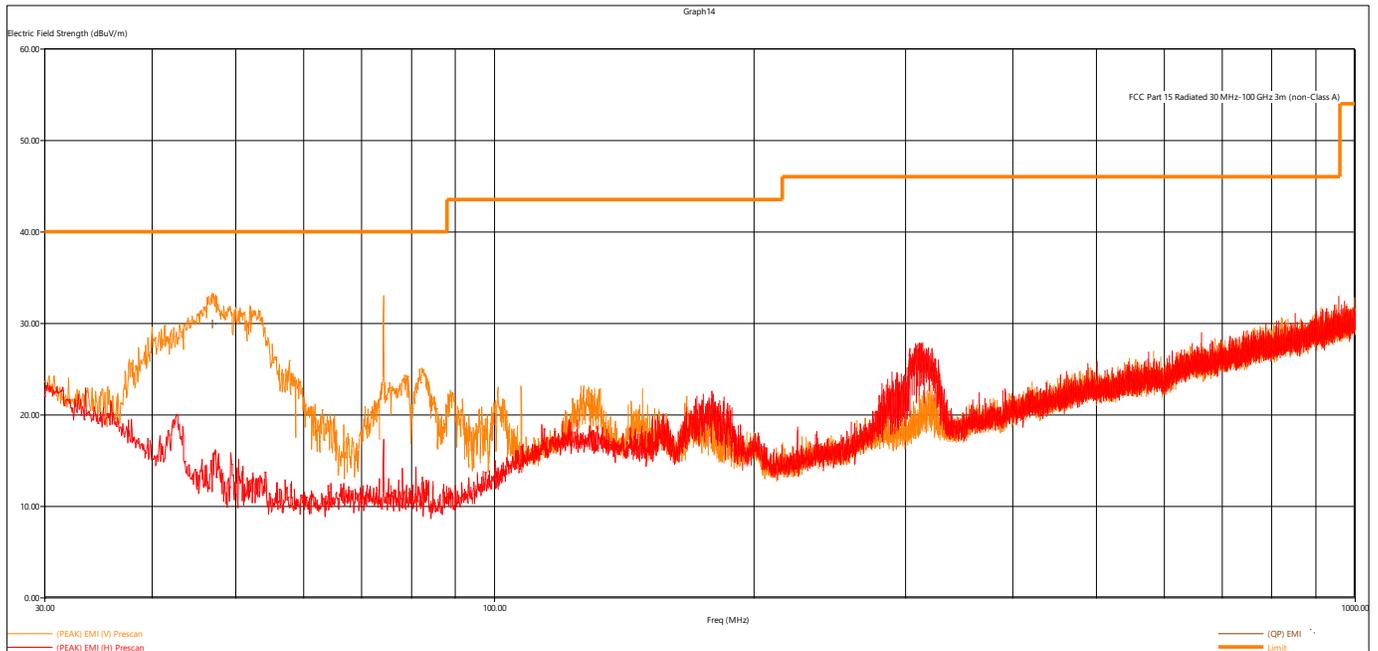


Figure 9 - Radiated Emissions Plot, 802.11n MCS0

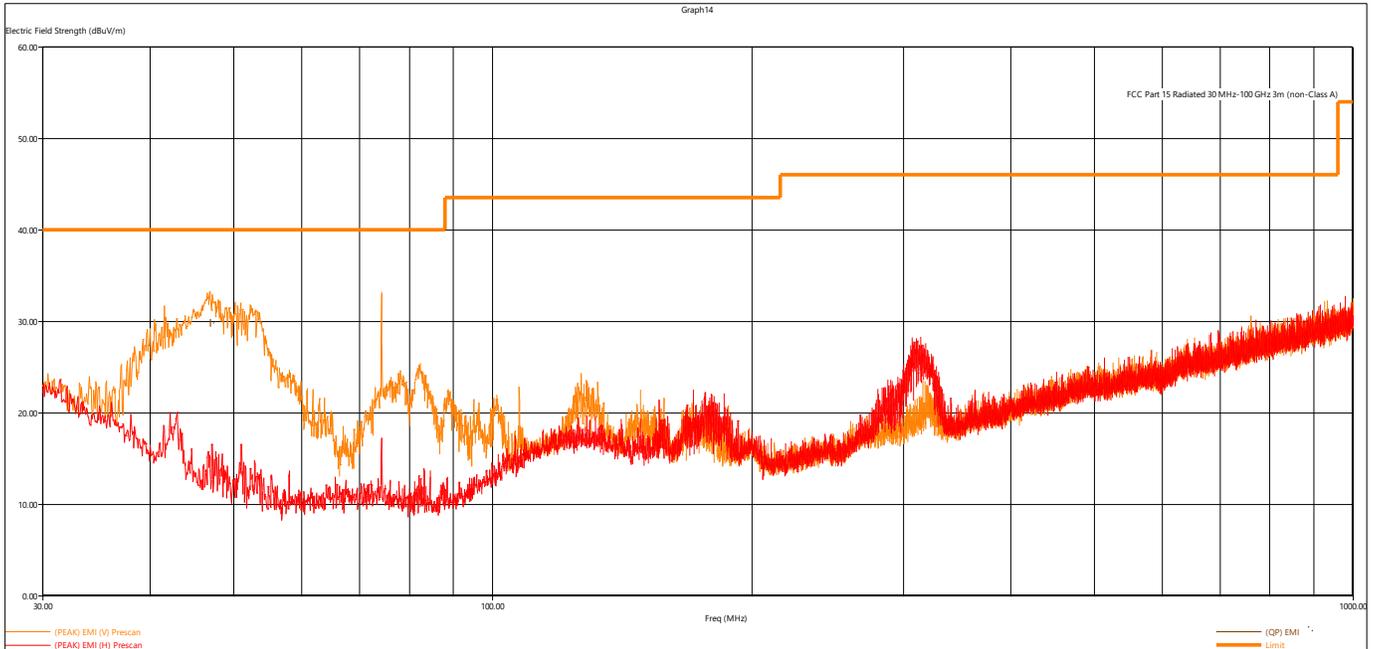


Figure 10 - Radiated Emissions Plot, 802.11n MCS7

**REMARKS:**

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level - Limit value

Quasi-Peak Measurements, 802.11x								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBμV/m	dBμV/m	dB	cm.	deg.			
46.806720	29.32	40.00	10.68	107.00	207.00	V	Low	802.11b 1MB
47.449200	28.70	40.00	11.30	109.00	246.00	V	Low	802.11b 11MB
47.005920	30.09	40.00	9.91	108.00	26.00	V	Low	802.11g 6MB
46.906080	29.62	40.00	10.38	104.00	231.00	V	Low	802.11g 54MB
47.034960	29.87	40.00	10.13	108.00	8.00	V	Low	802.11n MCS0
46.938240	29.80	40.00	10.20	109.00	318.00	V	Low	802.11n MCS7
46.431840	28.41	40.00	11.59	106.00	235.00	V		Receive

All other measurements were found to be at least 6 dB below the limit. Worst case emissions are reported.

Peak Measurements, 802.11x								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBμV/m	dBμV/m	dB	cm.	deg.			
2411.094000	101.97	NA	NA	154.00	7.00	V	Low	802.11b 1MB
2437.856000	104.82	NA	NA	132.00	3.00	V	Mid	802.11b 1MB
2461.052000	102.27	NA	NA	184.00	358.00	V	High	802.11b 1MB



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2411.906000	106.03	NA	NA	158.00	4.00	V	Low	802.11b 11MB
2435.424000	108.51	NA	NA	189.00	360.00	V	Mid	802.11b 11MB
2463.212000	106.90	NA	NA	128.00	360.00	V	High	802.11b 11MB
2414.330000	99.02	NA	NA	148.00	360.00	V	Low	802.11g 6MHz
2437.900000	105.40	NA	NA	129.00	360.00	V	Mid	802.11g 6MHz
2460.550000	100.08	NA	NA	177.00	359.00	V	High	802.11g 6MHz
2413.812000	101.20	NA	NA	311.00	350.00	V	Low	802.11g 54MHz
2438.594000	105.33	NA	NA	216.00	354.00	V	Mid	802.11g 54MHz
2460.324000	100.30	NA	NA	340.00	360.00	V	High	802.11g 54MHz
2414.154000	98.88	NA	NA	303.00	10.00	V	Low	802.11n MCS0
2438.400000	105.77	NA	NA	224.00	352.00	V	Mid	802.11n MCS0
2460.604000	99.78	NA	NA	253.00	349.00	V	High	802.11n MCS0
2413.658000	101.28	NA	NA	303.00	355.00	V	Low	802.11n MCS7
2437.520000	103.20	NA	NA	217.00	351.00	V	Mid	802.11n MCS7
2460.194000	101.38	NA	NA	252.00	354.00	V	High	802.11n MCS7

The EUT was maximized on all 3 orthogonal axes. The worst-case is shown in the plot and table above.  
All other measurements were found to be at least 6 dB Below the limit.



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Average Measurements, 802.11x								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.			
2411.094000	99.14	NA	NA	154.00	7.00	V	Low	802.11b 1MB
2437.856000	101.84	NA	NA	132.00	3.00	V	Mid	802.11b 1MB
2461.052000	99.38	NA	NA	184.00	358.00	V	High	802.11b 1MB
2411.906000	98.38	NA	NA	158.00	4.00	V	Low	802.11b 11MB
2435.424000	100.77	NA	NA	189.00	360.00	V	Mid	802.11b 11MB
2463.212000	98.52	NA	NA	128.00	360.00	V	High	802.11b 11MB
2414.330000	89.83	NA	NA	148.00	360.00	V	Low	802.11g 6MHz
2437.900000	96.36	NA	NA	129.00	360.00	V	Mid	802.11g 6MHz
2460.550000	91.22	NA	NA	177.00	359.00	V	High	802.11g 6MHz
2413.812000	90.73	NA	NA	311.00	350.00	V	Low	802.11g 54MHz
2438.594000	95.02	NA	NA	216.00	354.00	V	Mid	802.11g 54MHz
2460.324000	90.32	NA	NA	340.00	360.00	V	High	802.11g 54MHz
2414.154000	89.45	NA	NA	303.00	10.00	V	Low	802.11n MCS0
2438.400000	96.62	NA	NA	224.00	352.00	V	Mid	802.11n MCS0
2460.604000	90.20	NA	NA	253.00	349.00	V	High	802.11n MCS0
2413.658000	90.34	NA	NA	303.00	355.00	V	Low	802.11n MCS7
2437.520000	93.51	NA	NA	217.00	351.00	V	Mid	802.11n MCS7
2460.194000	90.86	NA	NA	252.00	354.00	V	High	802.11n MCS7

The EUT was maximized on all 3 orthogonal axes. The worst-case is shown in the plot and table above. All other measurements were found to be at least 6 dB Below the limit.



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#### 4.5 CONDUCTED SPURIOUS EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.7

**Limits of spurious emissions:**

From FCC Part 15.247:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

**Test procedures:**

The highest emissions level was measured and recorded. All spurious measurements were evaluated to 30dB below the fundamental. More details can be found in section 3.4 of this report. The line shown in the plots is a reference line placed at -20dBm.

**Deviations from test standard:**

Test performed at 120kHz RBW

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

Data rates and channels were investigated and worst case was reported, no emissions exceeded the limits.

There was no distinguishable difference between low and high data rate.

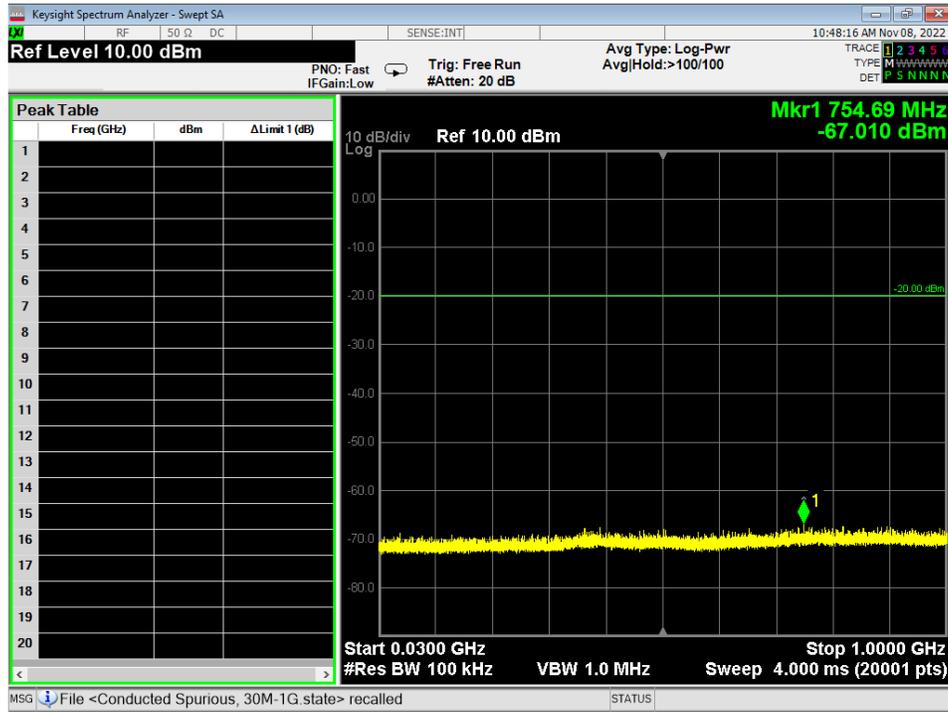


Figure 11 - Radiated Emissions Plot, WIFI 802.11b, 30M – 1G, Low

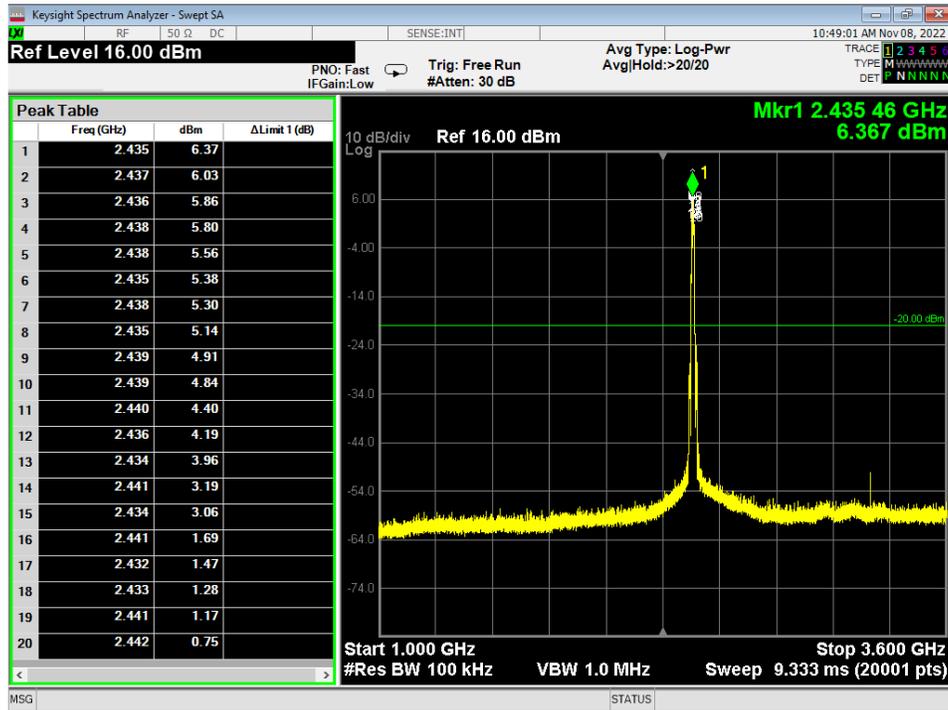


Figure 12 - Radiated Emissions Plot, WIFI 802.11b, 1G – 3.6G, Low

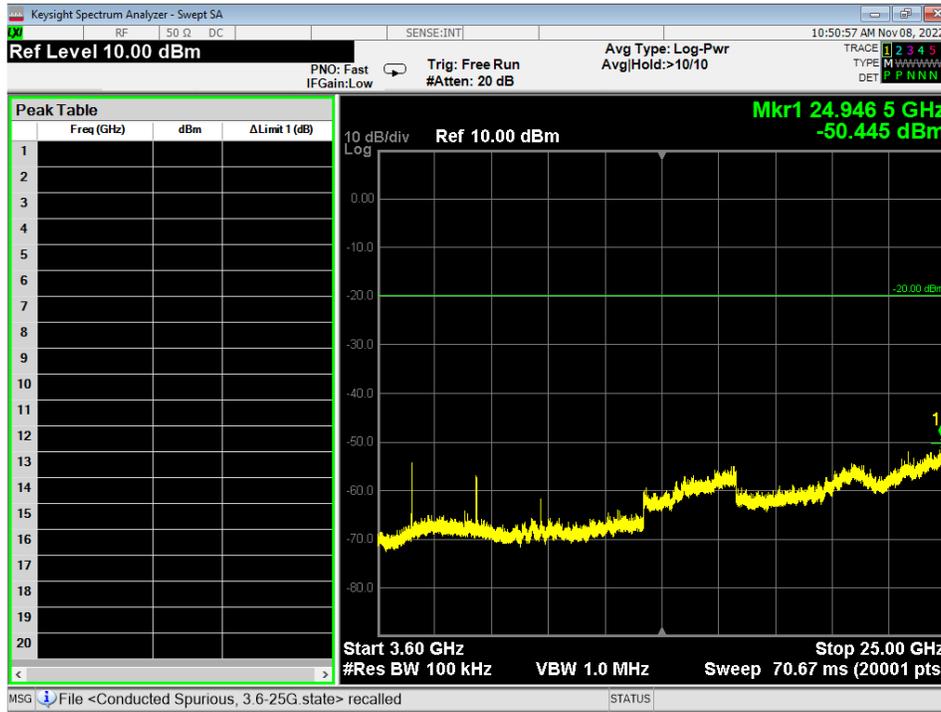


Figure 13 - Radiated Emissions Plot, WIFI 802.11b, 3.6G – 25G, Low

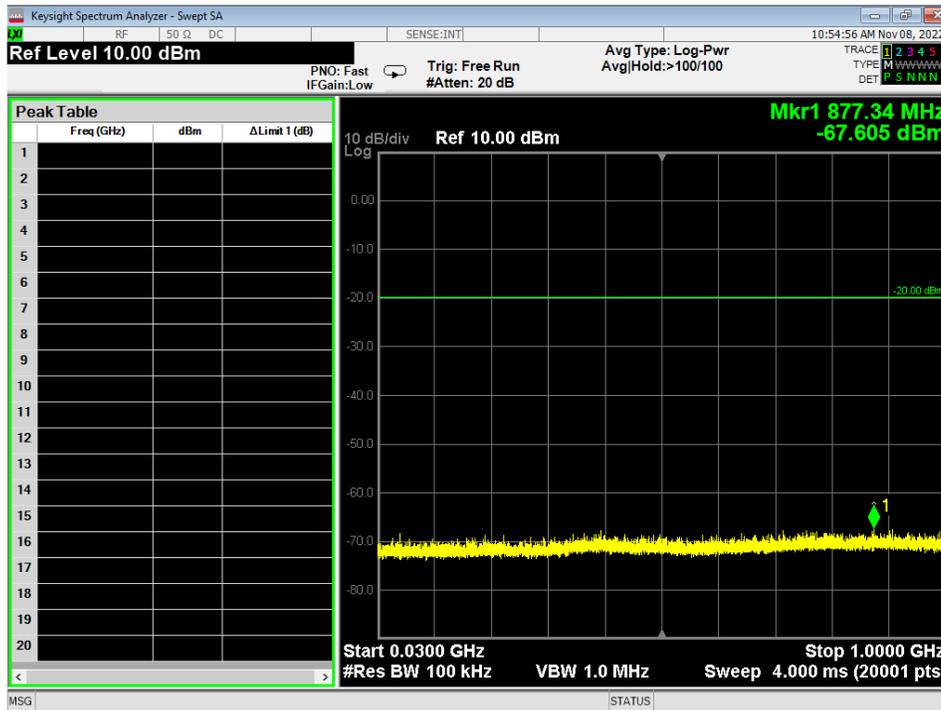


Figure 14 - Radiated Emissions Plot, WIFI 802.11g, 30M – 1G, Low

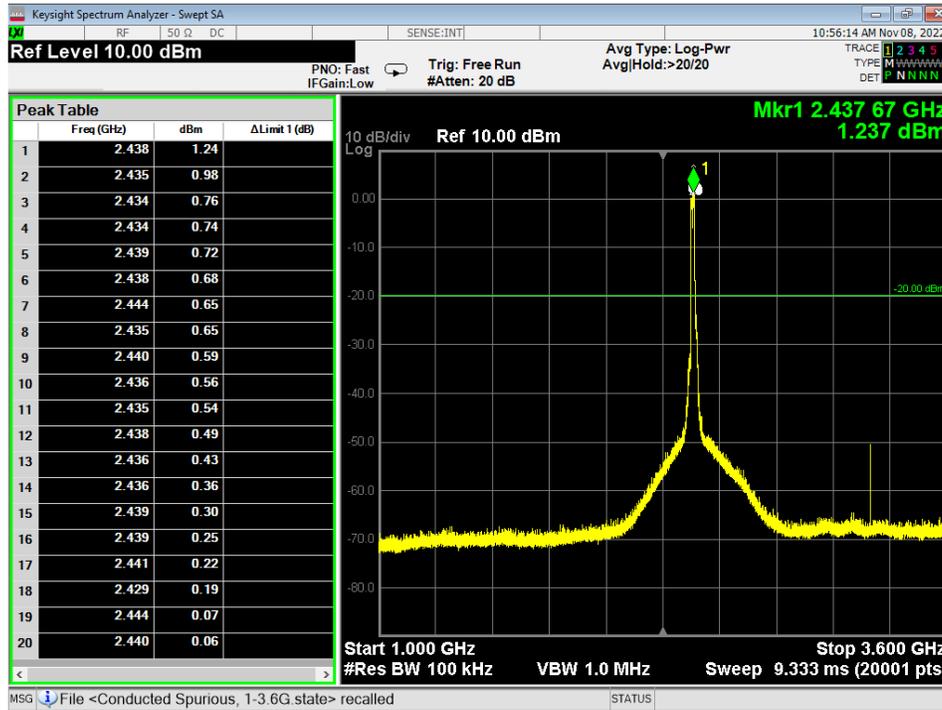


Figure 15 - Radiated Emissions Plot, WIFI 802.11g, 1G – 3.6G, Low

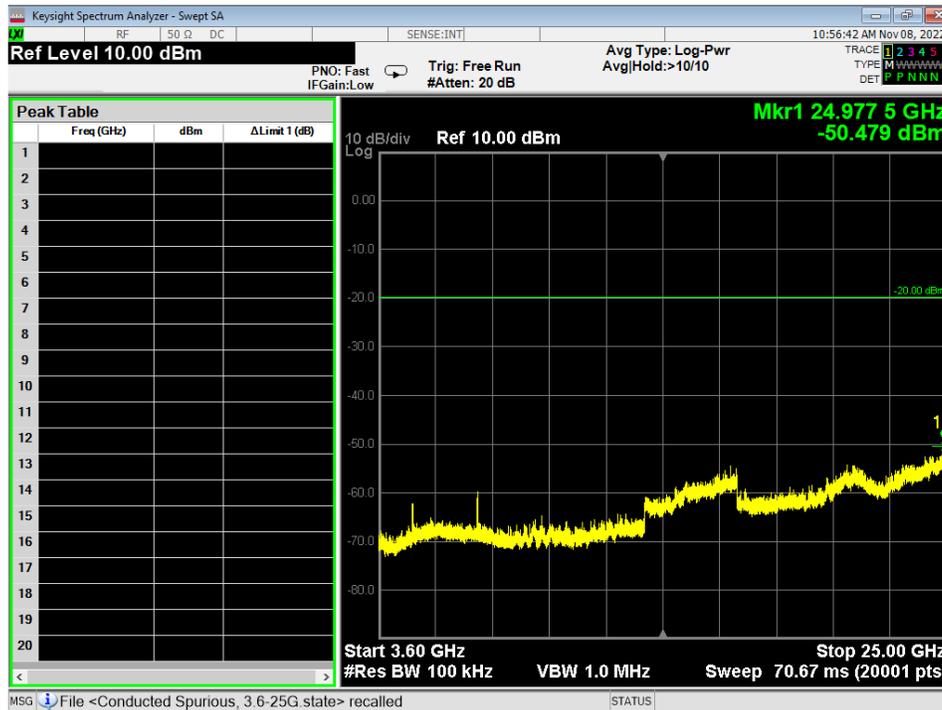


Figure 16 - Radiated Emissions Plot, WIFI 802.11g, 3.6G – 25G, Low

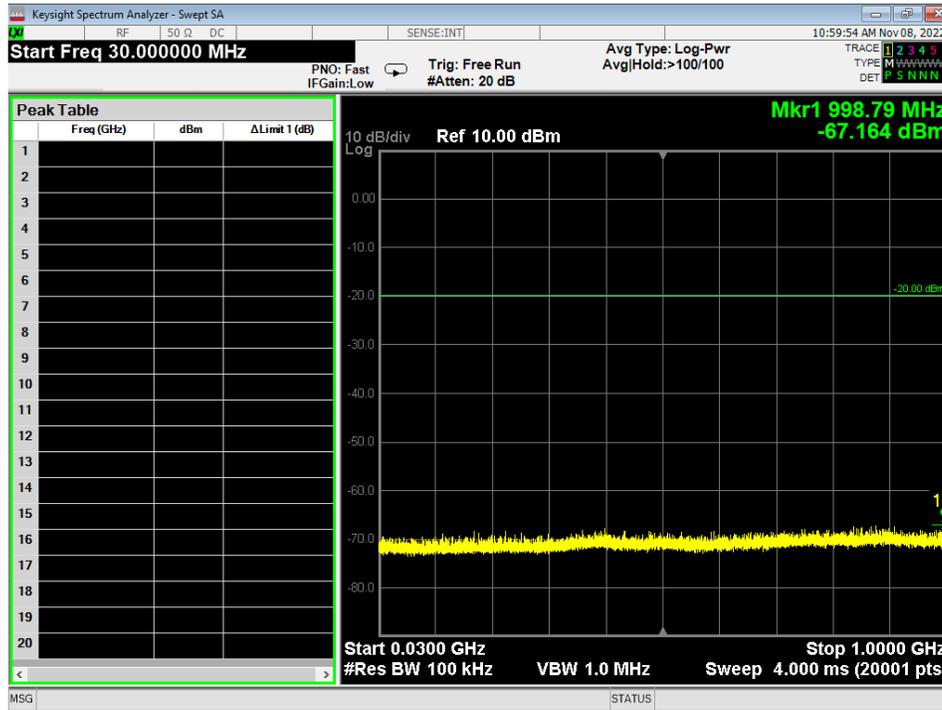


Figure 17 - Radiated Emissions Plot, WIFI 802.11n, 30M – 1G, Low

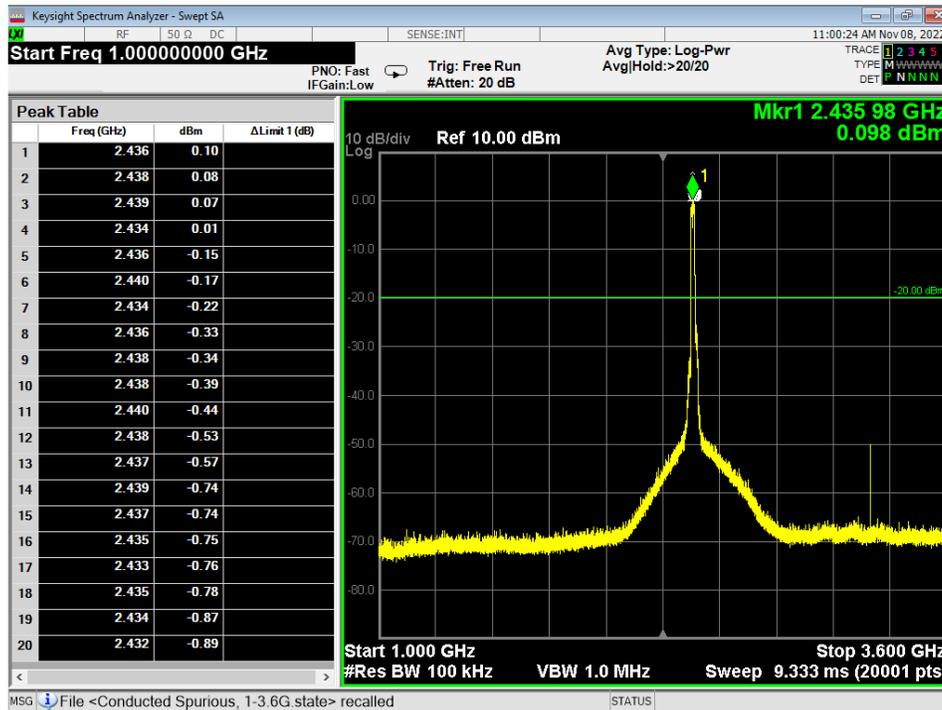


Figure 18 - Radiated Emissions Plot, WIFI 802.11n, 1G – 3.6G, Low

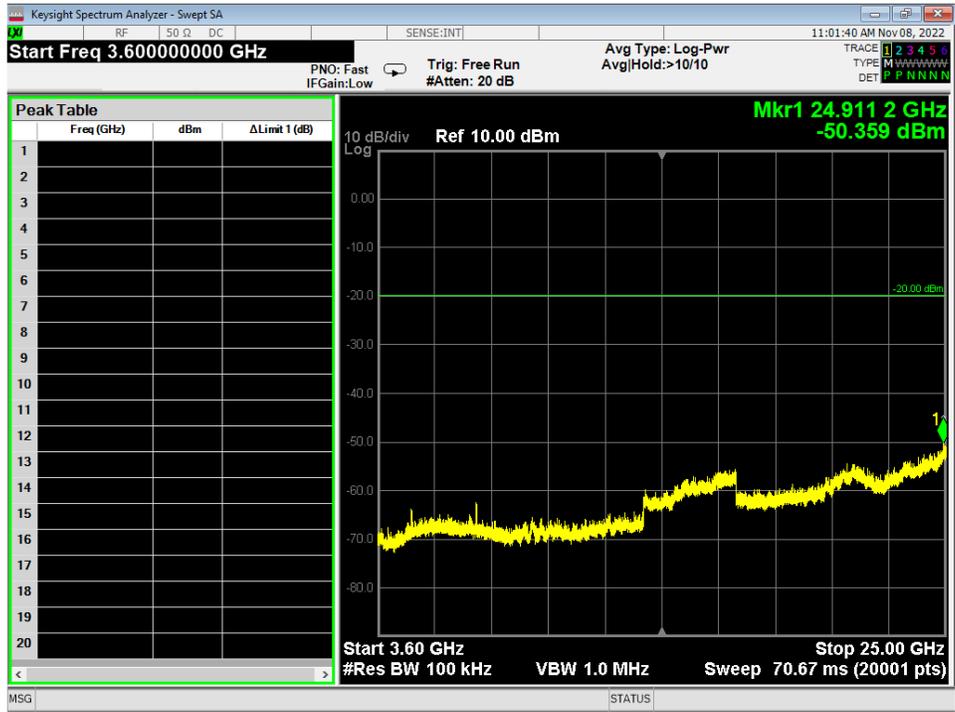


Figure 19 - Radiated Emissions Plot, WIFI 802.11n, 3.6G – 25G, Low

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#### 4.6 BAND EDGES

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of band-edge measurements:**

**For FCC Part 15.247 Device:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

**Test procedures:**

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.



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**Test results:**

**Pass**

Comments:

1. All the band edge plots can be found in the Appendix C.
2. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.



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## 4.7 POWER SPECTRAL DENSITY

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of power measurements:**

**For FCC Part 15.247 Device:**

The maximum PSD allowed is 8 dBm.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the Power Spectral Density (PSD) plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are reported on the graph.
4. The measurements are listed in the tables in section 4.0.

## 4.8 CONDUCTED AC MAINS EMISSIONS

**Test Method:** ANSI C63.10-2013, Section(s) 6.2

**Limits for conducted emissions measurements:**

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dB $\mu$ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

**Notes:**

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

**Test Procedures:**

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

**Deviation from the test standard:**

No deviation

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

Test Results:

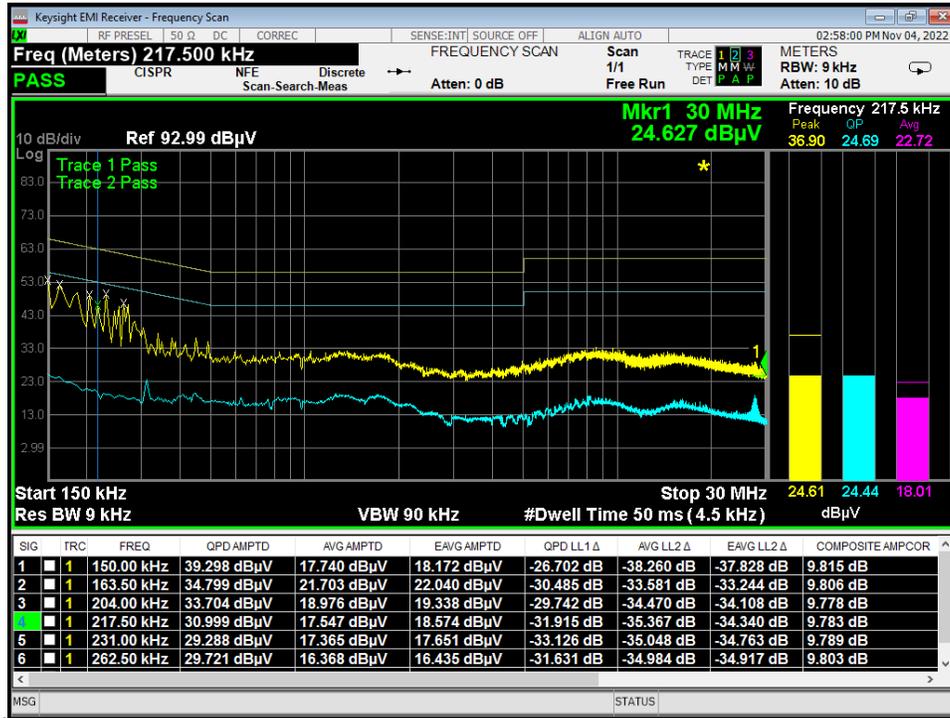


Figure 20 - Conducted Emissions Plot, Line, TX



Figure 21 - Conducted Emissions Plot, Neutral, TX



Figure 22 - Conducted Emissions Plot, Line, IDLE



Figure 23 - Conducted Emissions Plot, Neutral, IDLE



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**APPENDIX A: SAMPLE CALCULATION**

**Field Strength Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

- RA = Receiver Amplitude
- AF = Antenna Factor
- CF = Cable Attenuation Factor
- AG = Amplifier Gain
- AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB $\mu$ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB $\mu$ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by the taking the  $20 \cdot \log(T_{on}/100)$  where  $T_{on}$  is the maximum transmission time in any 100ms window.



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### EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

$$EIRP \text{ (Watts)} = [\text{Field Strength (V/m)} \times \text{antenna distance (m)}]^2 / 30$$

$$\text{Power (watts)} = 10^{[\text{Power (dBm)}/10]} / 1000$$

$$\text{Voltage (dB}\mu\text{V)} = \text{Power (dBm)} + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$\text{Field Strength (V/m)} = 10^{[\text{Field Strength (dB}\mu\text{V/m)} / 20]} / 10^6$$

$$\text{Gain} = 1 \text{ (numeric gain for isotropic radiator)}$$

Conversion from 3m field strength to EIRP (d=3):

$$EIRP = [\text{FS(V/m)} \times d^2]/30 = \text{FS [0.3]} \quad \text{for } d = 3$$

$$EIRP(\text{dBm}) = \text{FS}(\text{dB}\mu\text{V/m}) - 10(\log 10^9) + 10\log[0.3] = \text{FS}(\text{dB}\mu\text{V/m}) - 95.23$$

*10log( 10^9) is the conversion from micro to milli*



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**APPENDIX B – MEASUREMENT UNCERTAINTY**

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

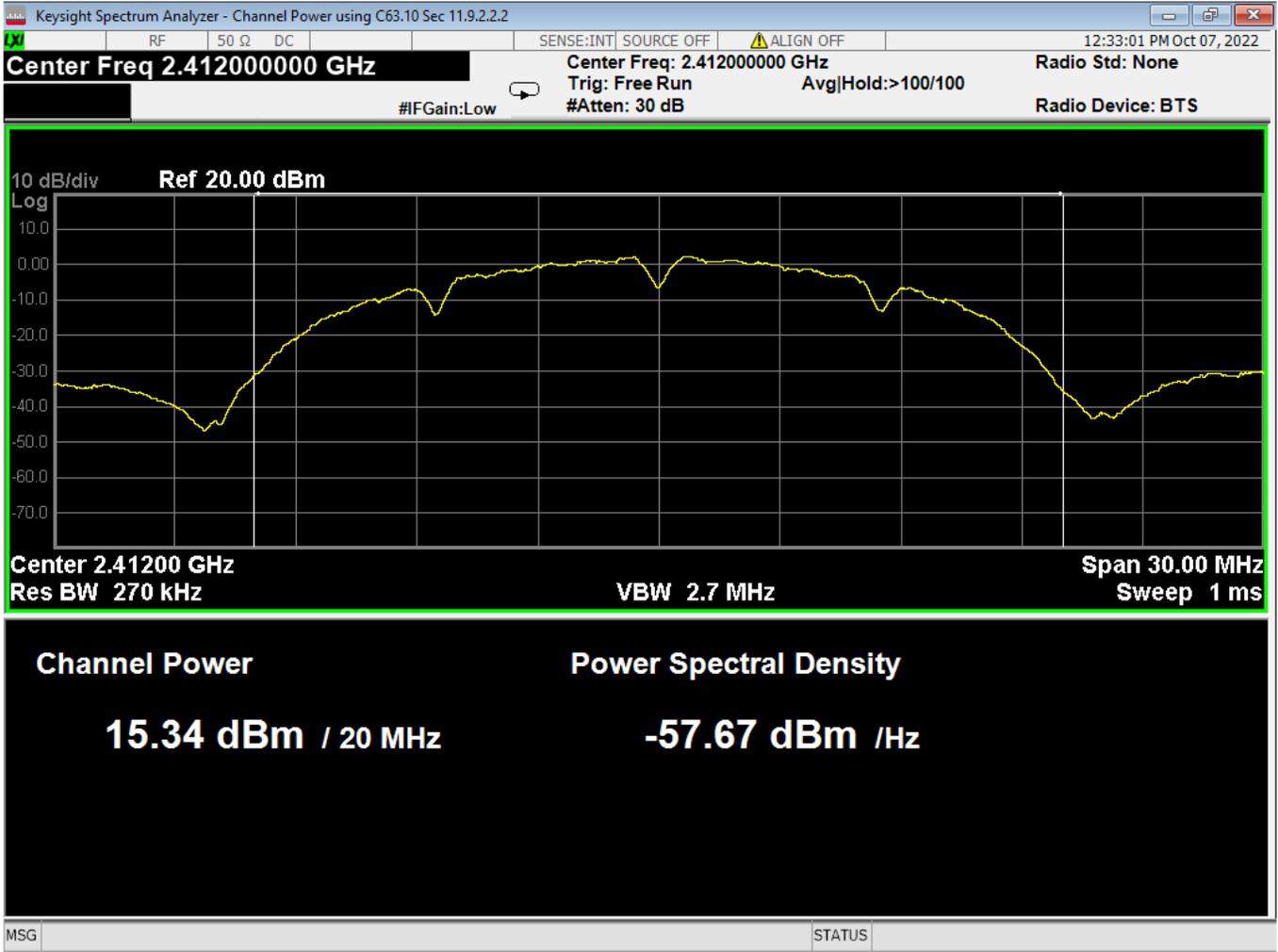
<b>Test</b>	<b>Frequency Range</b>	<b>Uncertainty Value (dB)</b>
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

Expanded uncertainty values are calculated to a confidence level of 95%.



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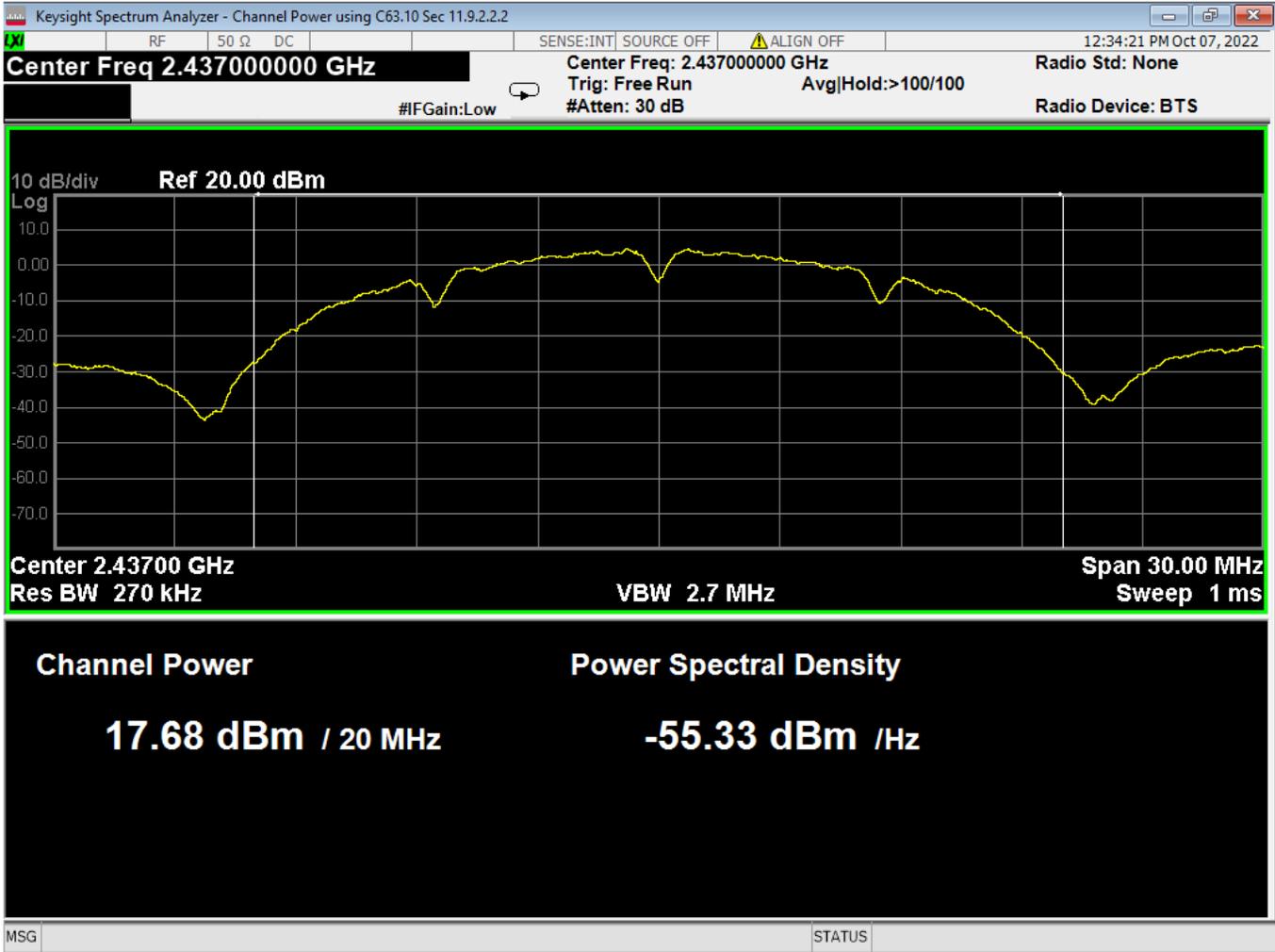
APPENDIX C – GRAPHS AND TABLES



01 Average Power, Low, Wifi B, Low Data Rate



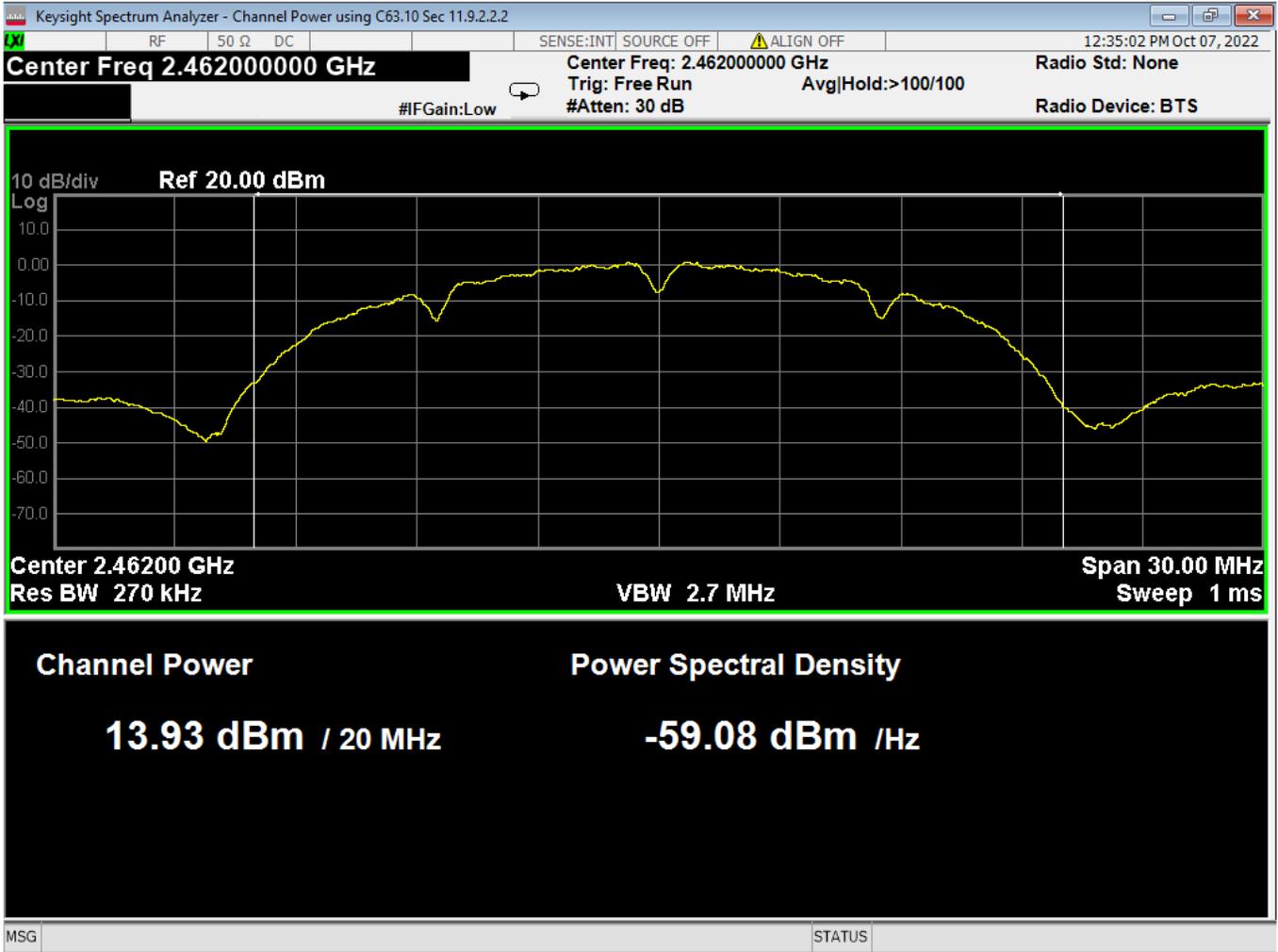
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02 Average Power, Mid, Wifi B, Low Data Rate



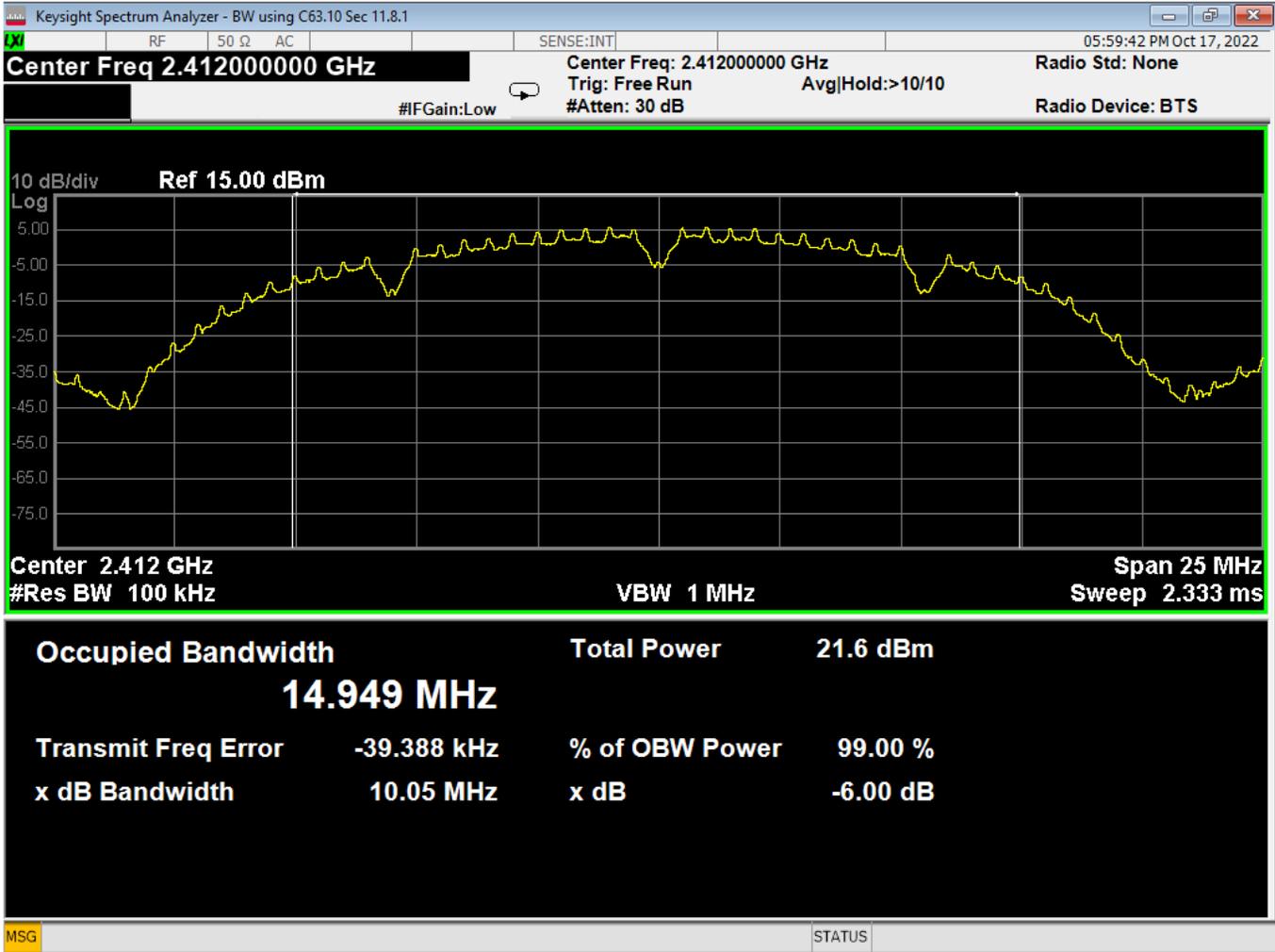
Report Number:	R20220901-21-E5A	Rev	A
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03 Average Power, High, Wifi B, Low Data Rate



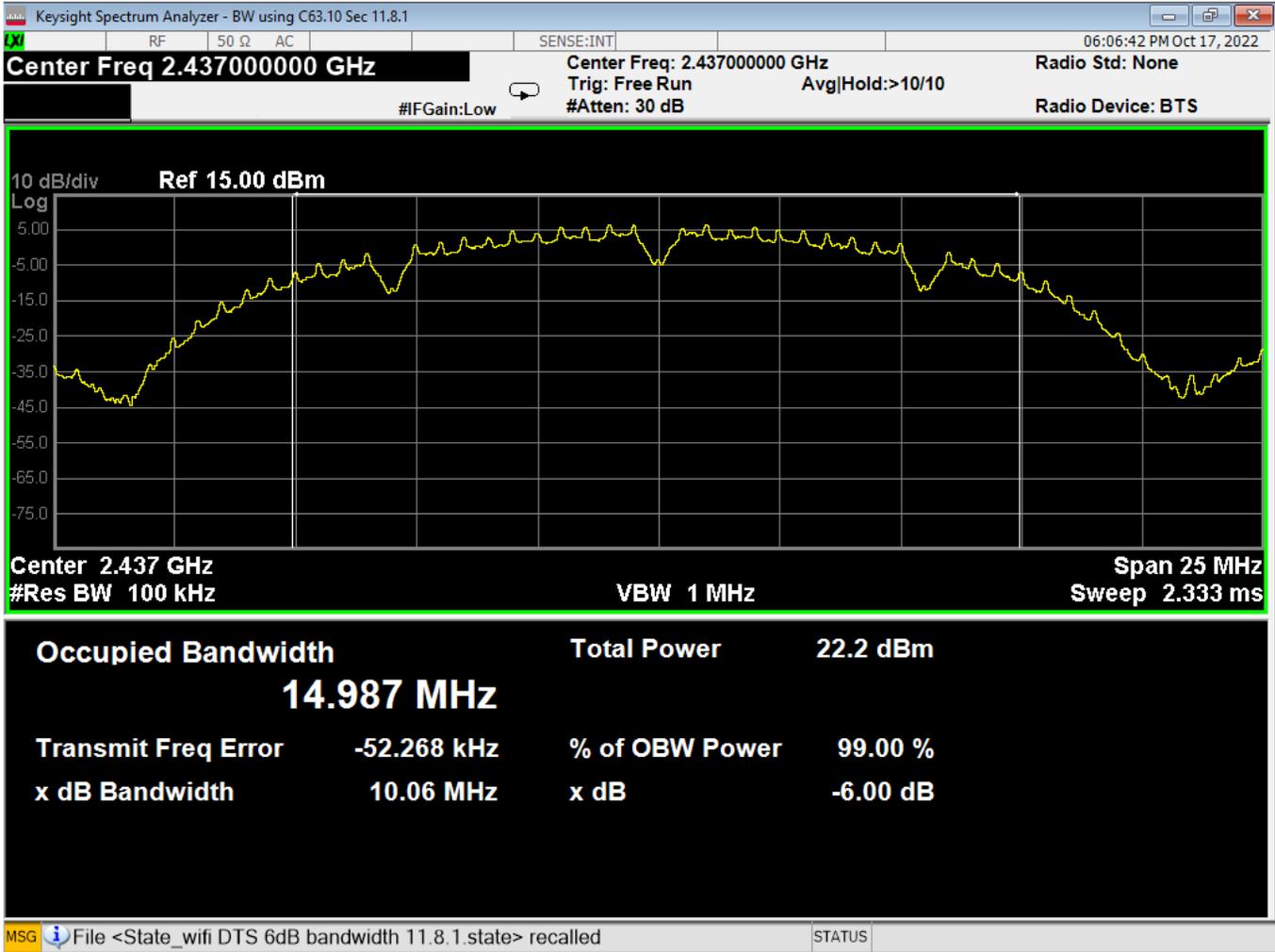
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04 6dB Bandwidth, Low, Wifi B, Low Data Rate



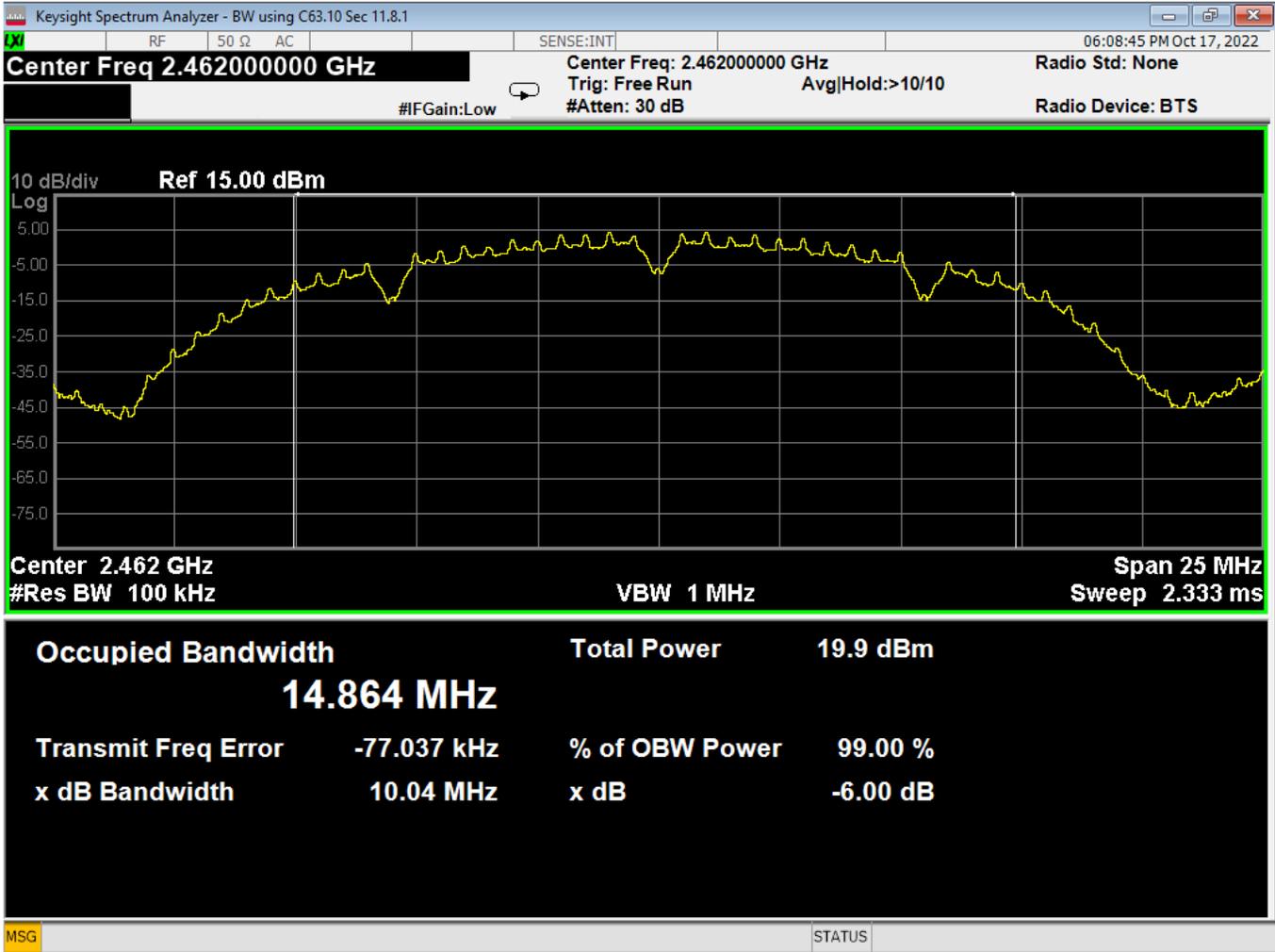
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05 6dB Bandwidth, Mid, Wifi B, Low Data Rate



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06 6dB Bandwidth, High, Wifi B, Low Data Rate



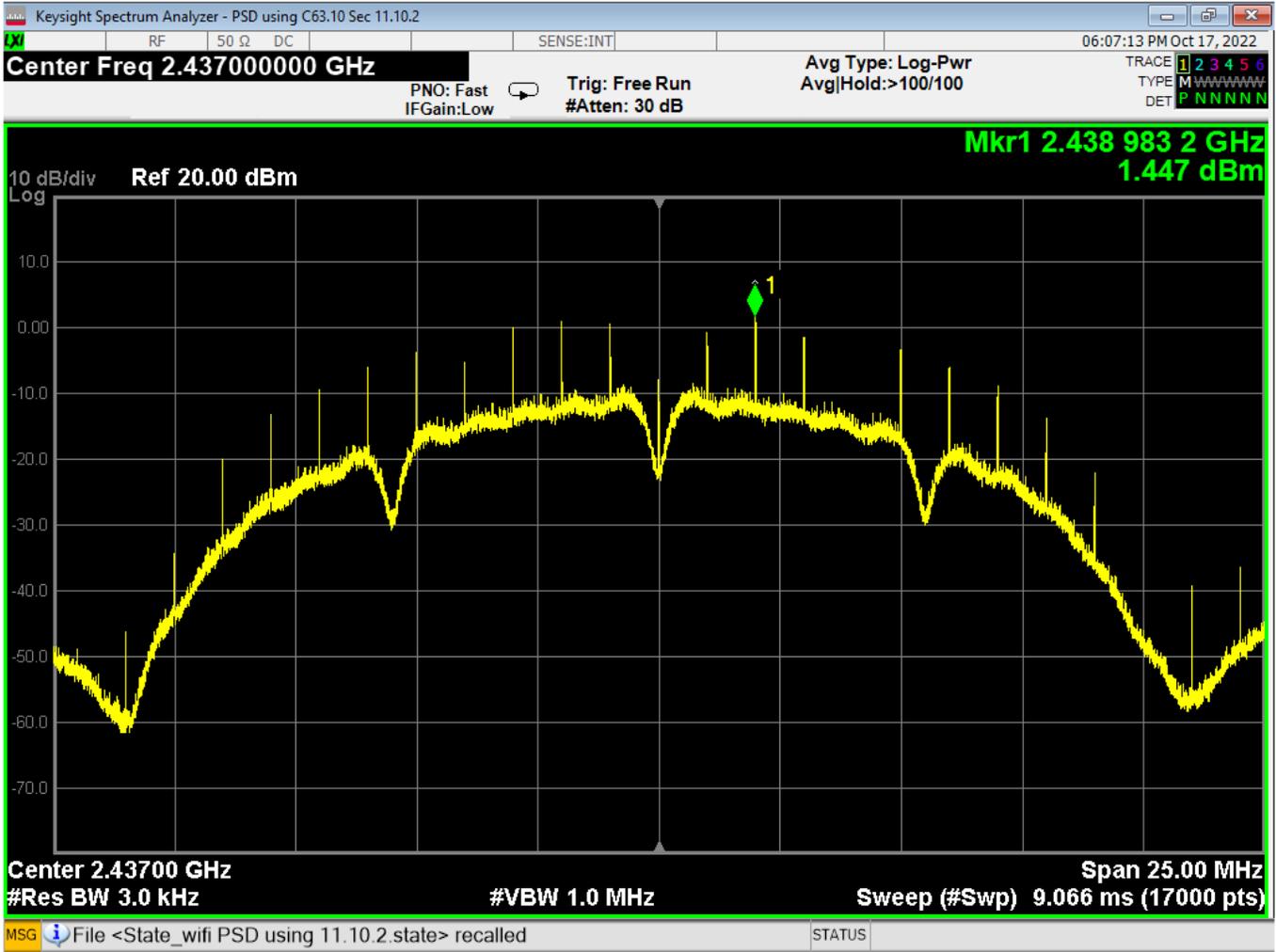
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07 PSD, Low, Wifi B, Low Data Rate



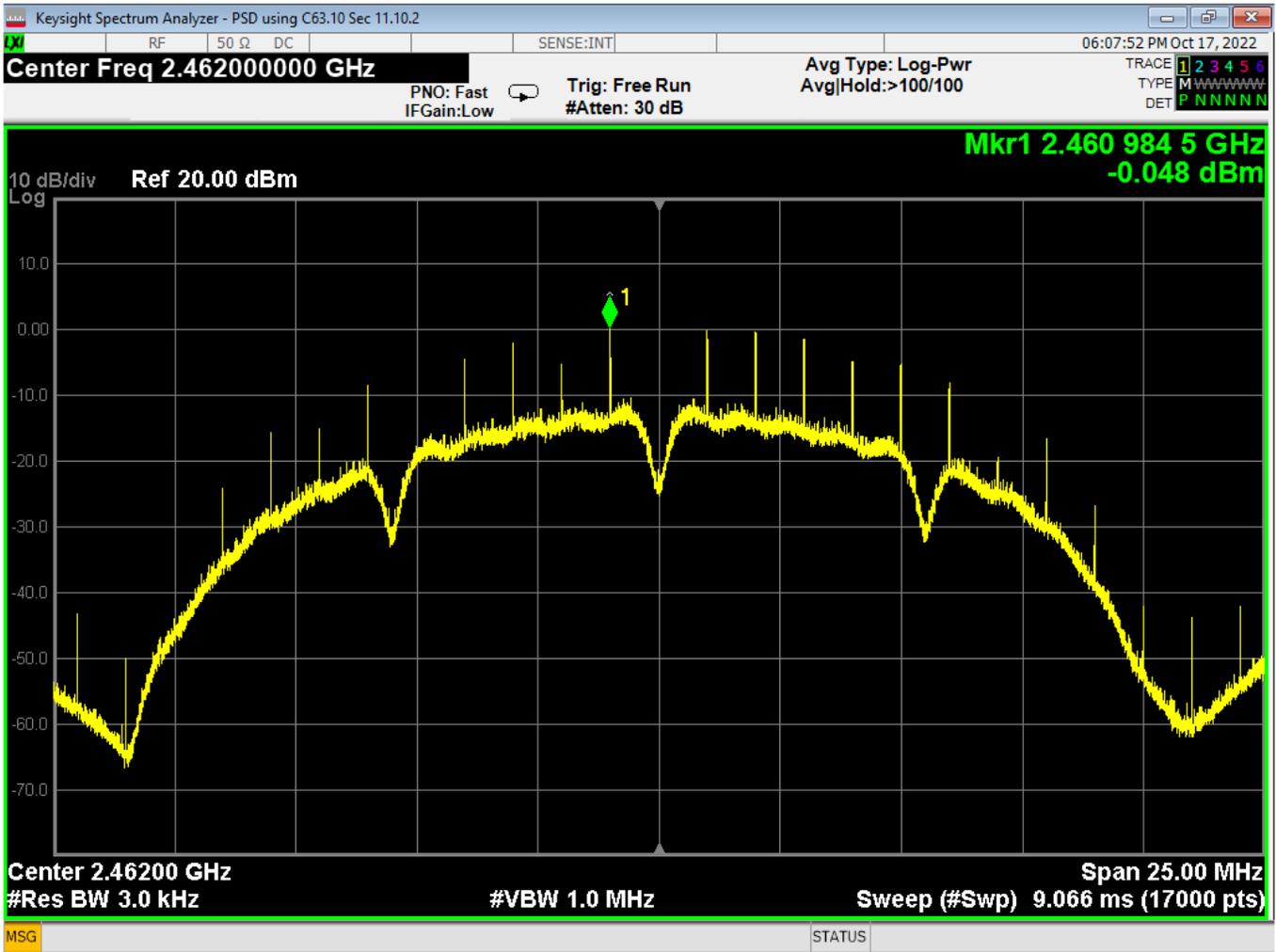
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



08 PSD, Mid, Wifi B, Low Data Rate



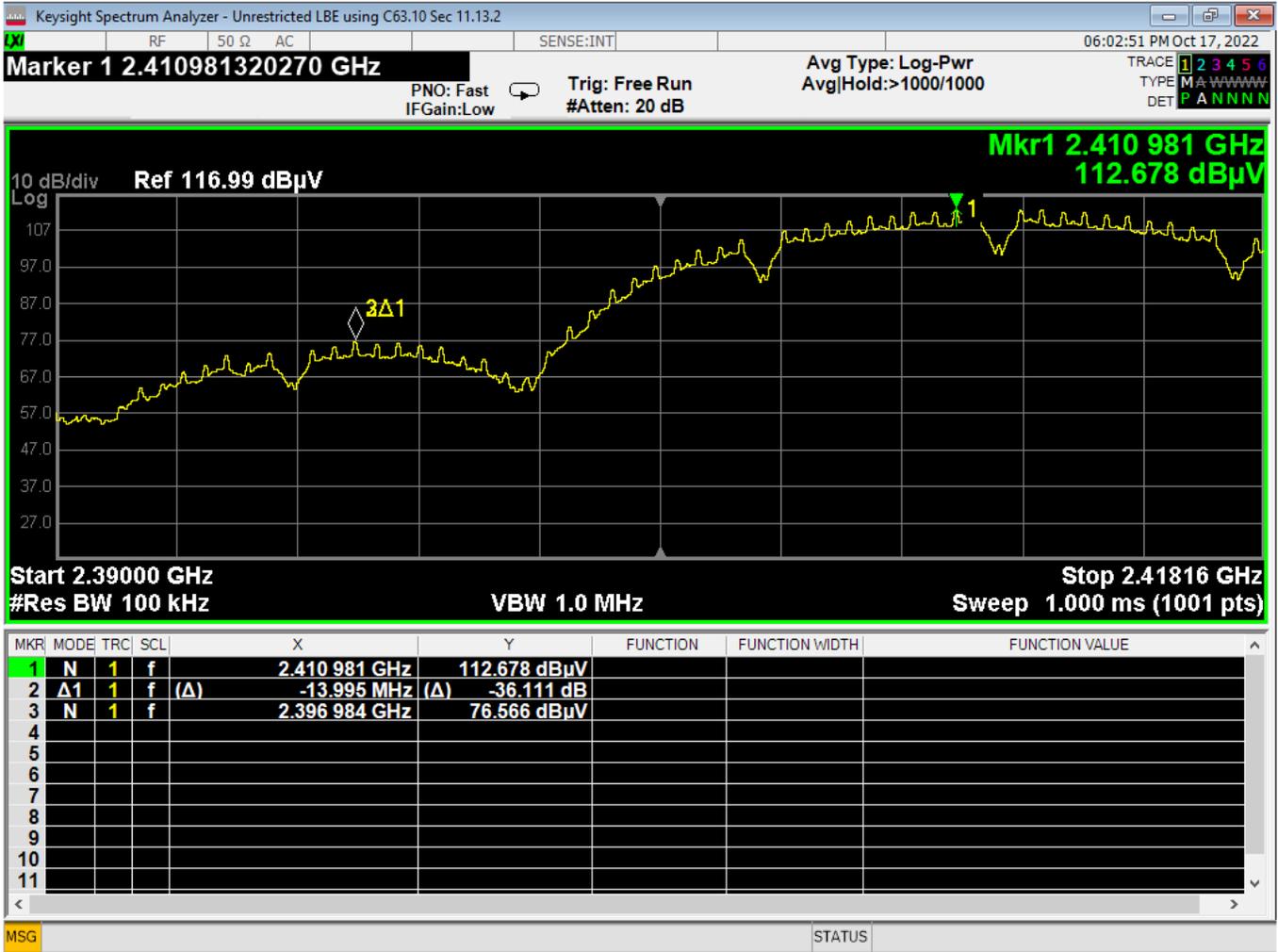
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



09 PSD, High, Wifi B, Low Data Rate



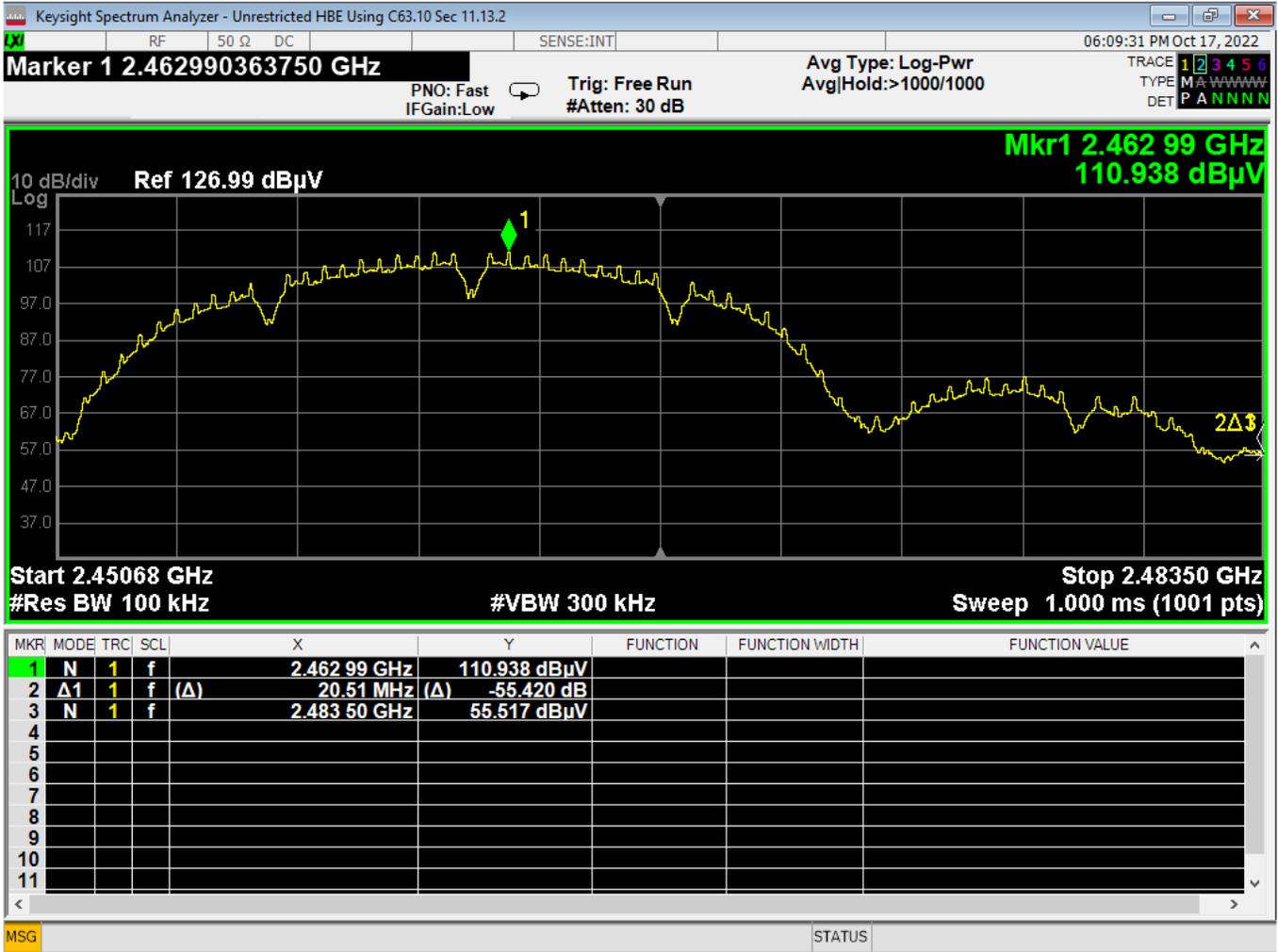
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



10 Lower Bandedge, Unrestricted, Wifi B, Low Data Rate



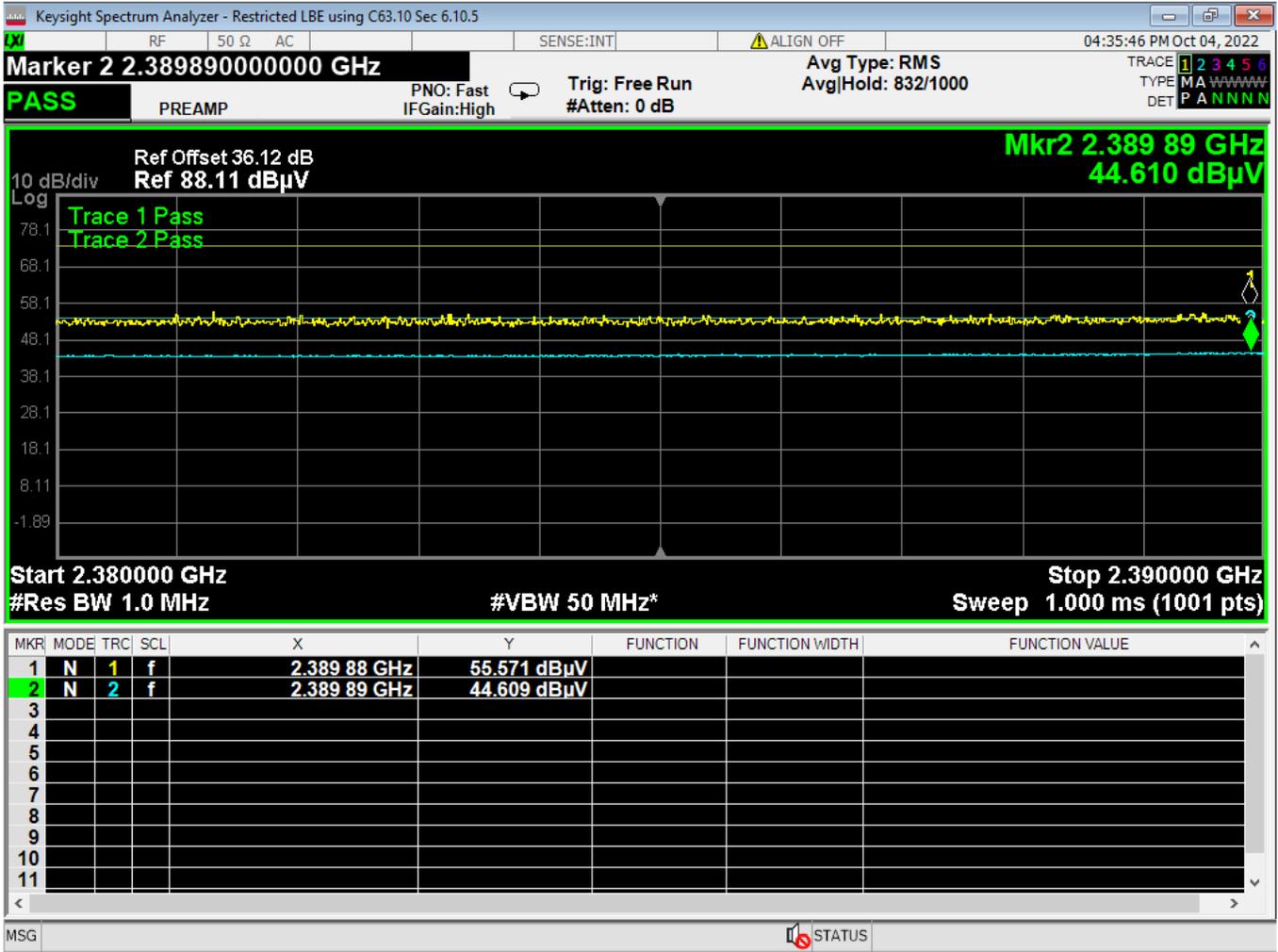
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



11 Higher Bandedge, Unrestricted, Wifi B, Low Data Rate



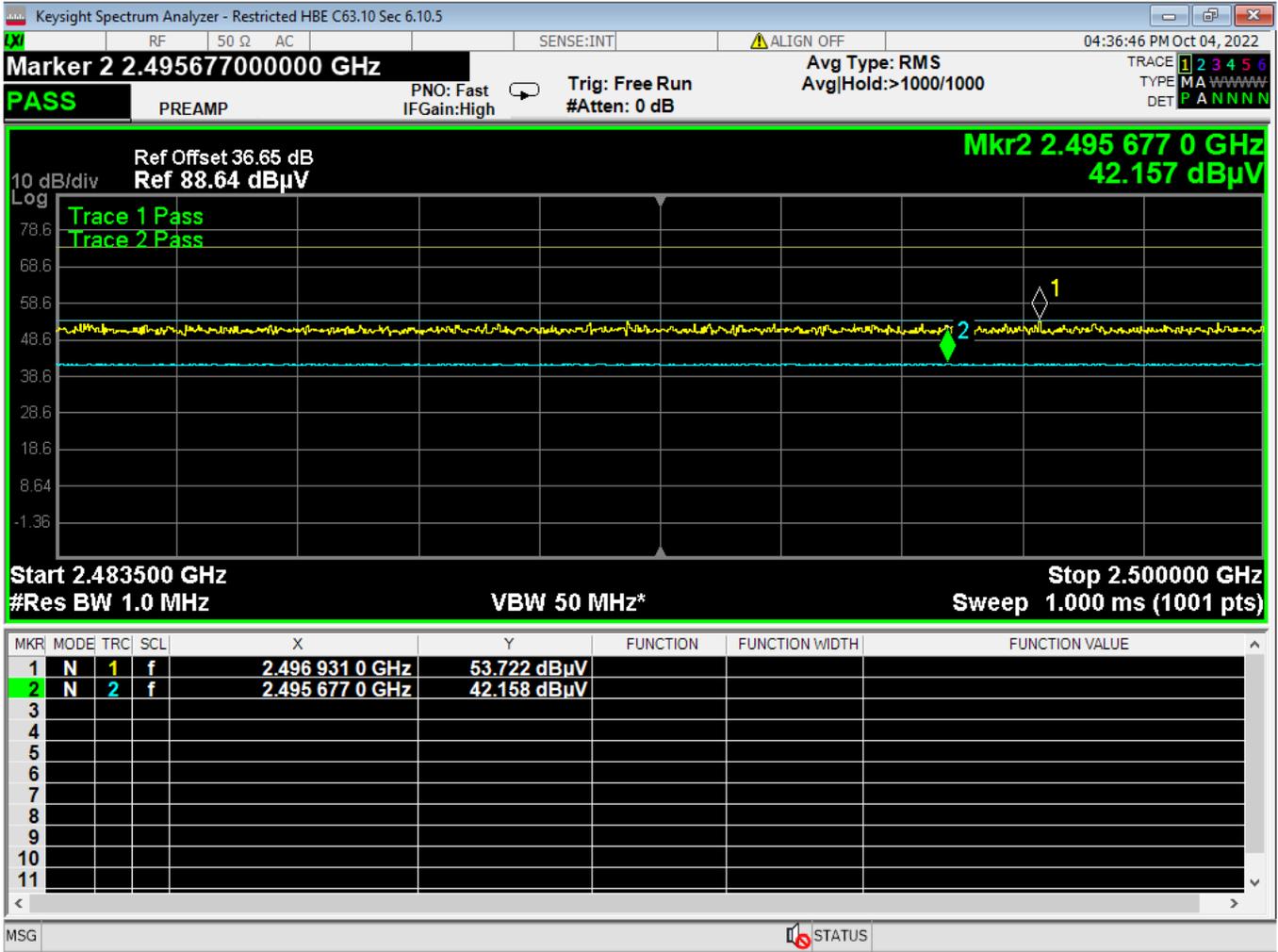
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



12 Lower Bandedge, Restricted, Wifi B, Low Data Rate



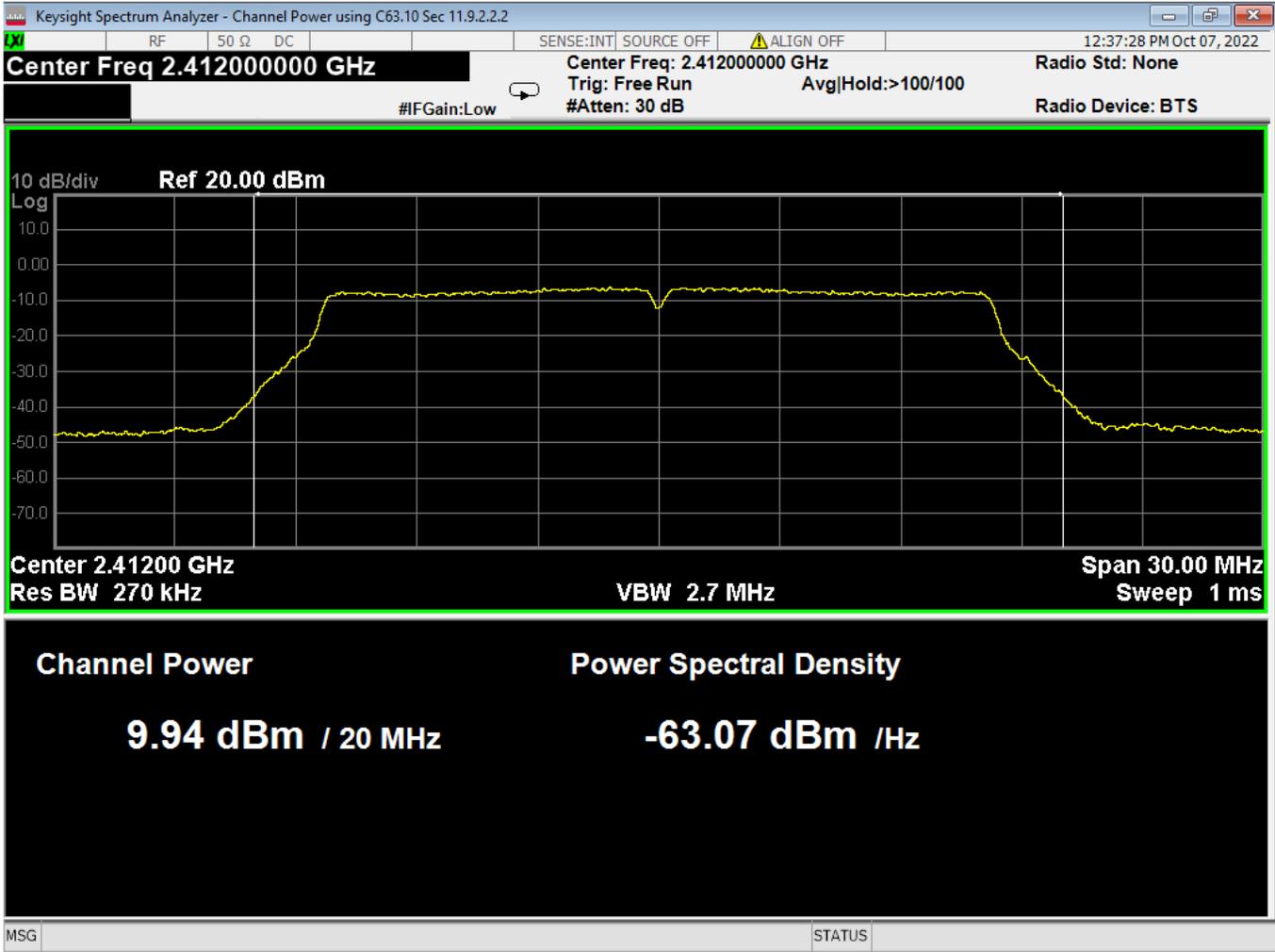
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



13 Higher Bandedge, Restricted, Wifi B, Low Data Rate



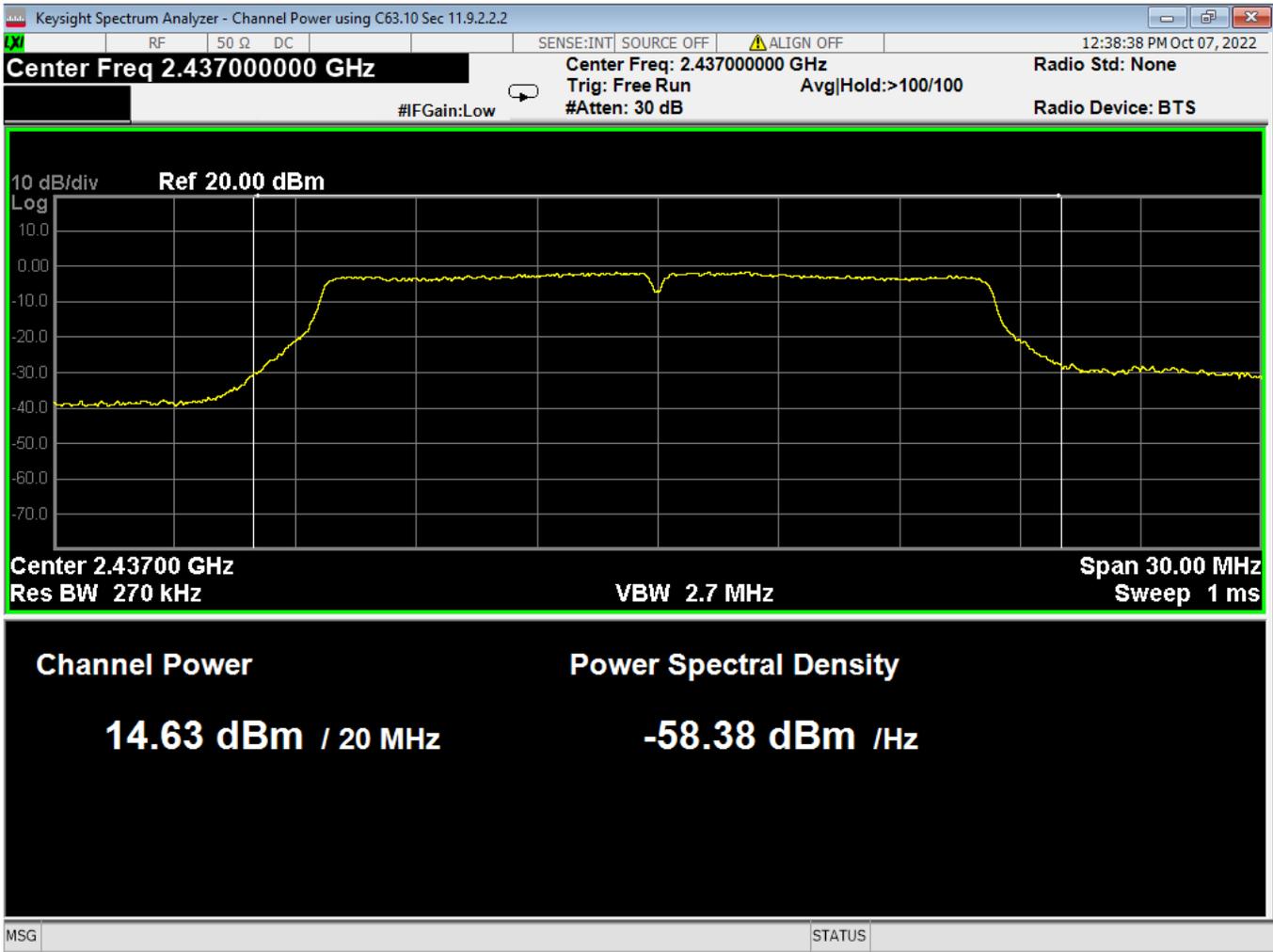
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



14 Average Power, Low, Wifi G, Low Data Rate



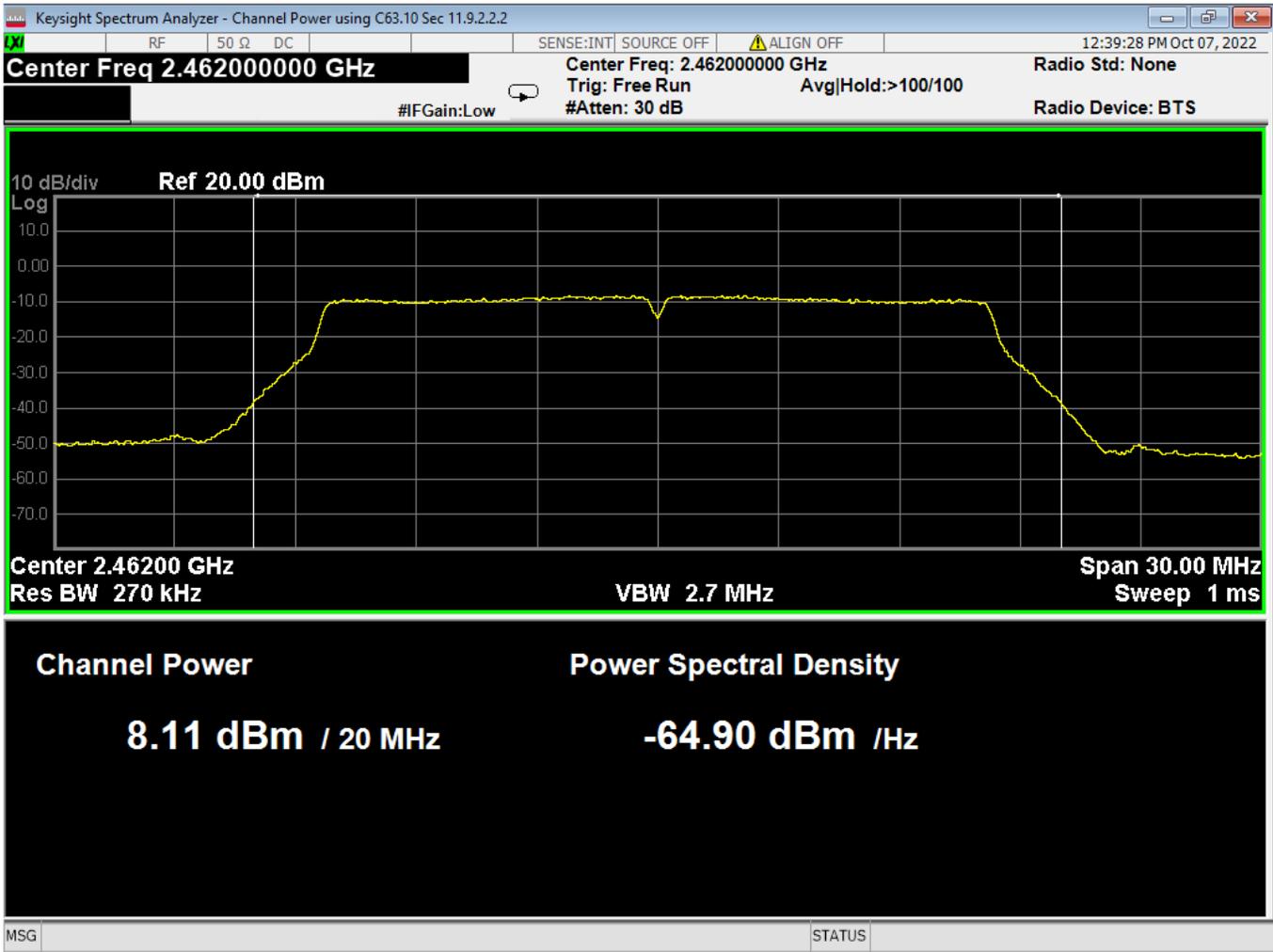
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



15 Average Power, Mid, Wifi G, Low Data Rate



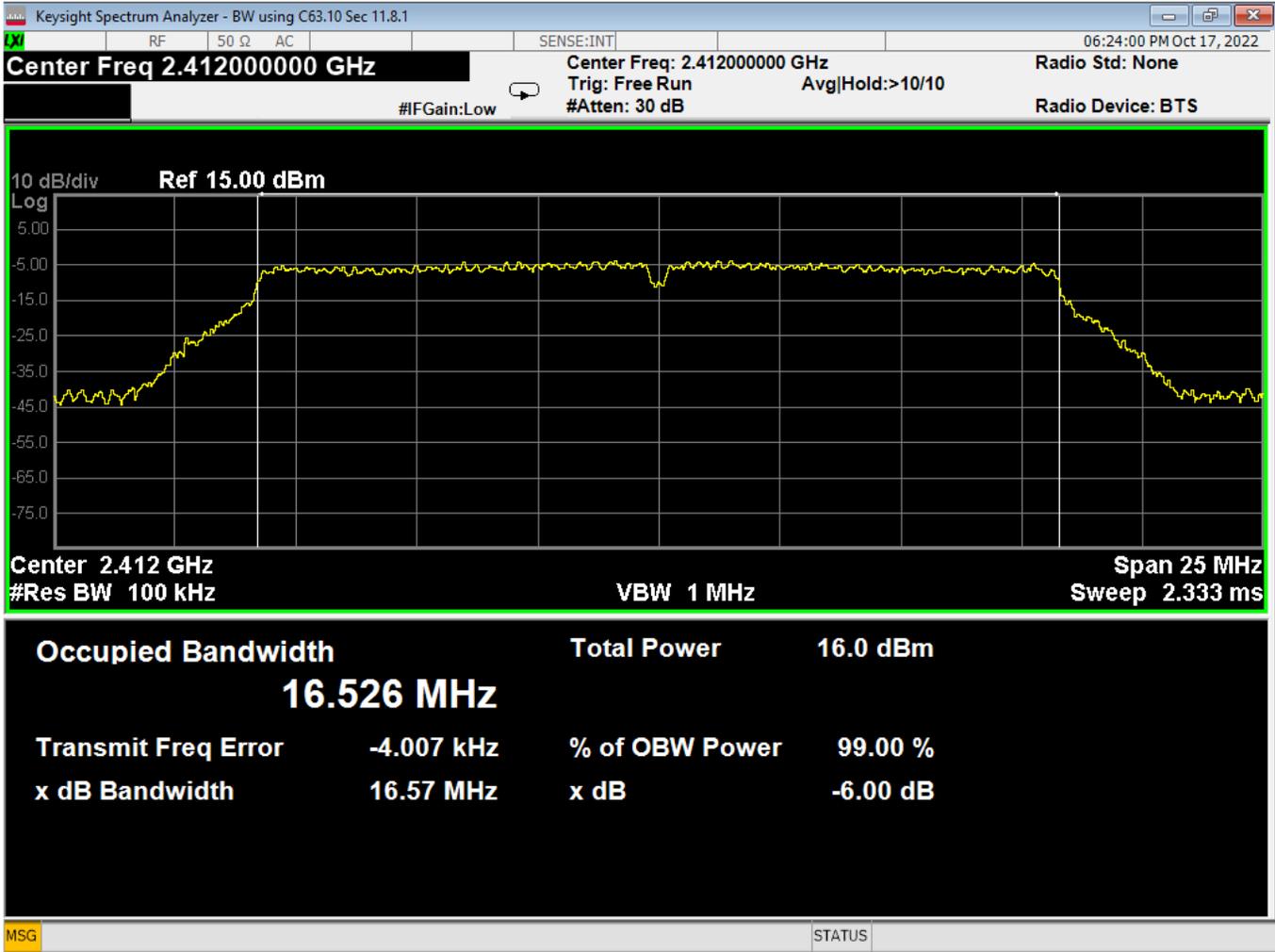
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



16 Average Power, High, Wifi G, Low Data Rate



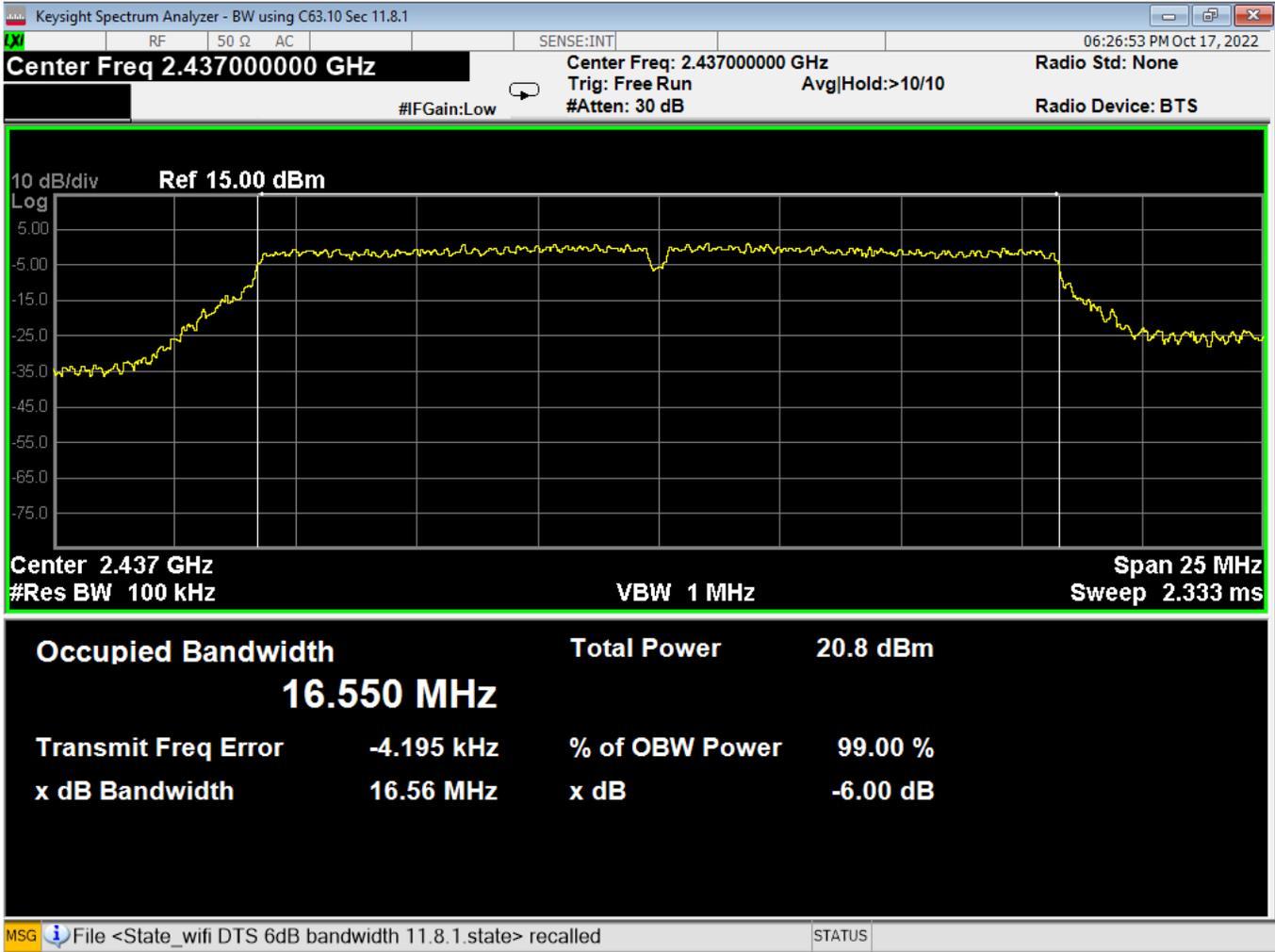
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



17 6dB Bandwidth, Low, Wifi G, Low Data Rate



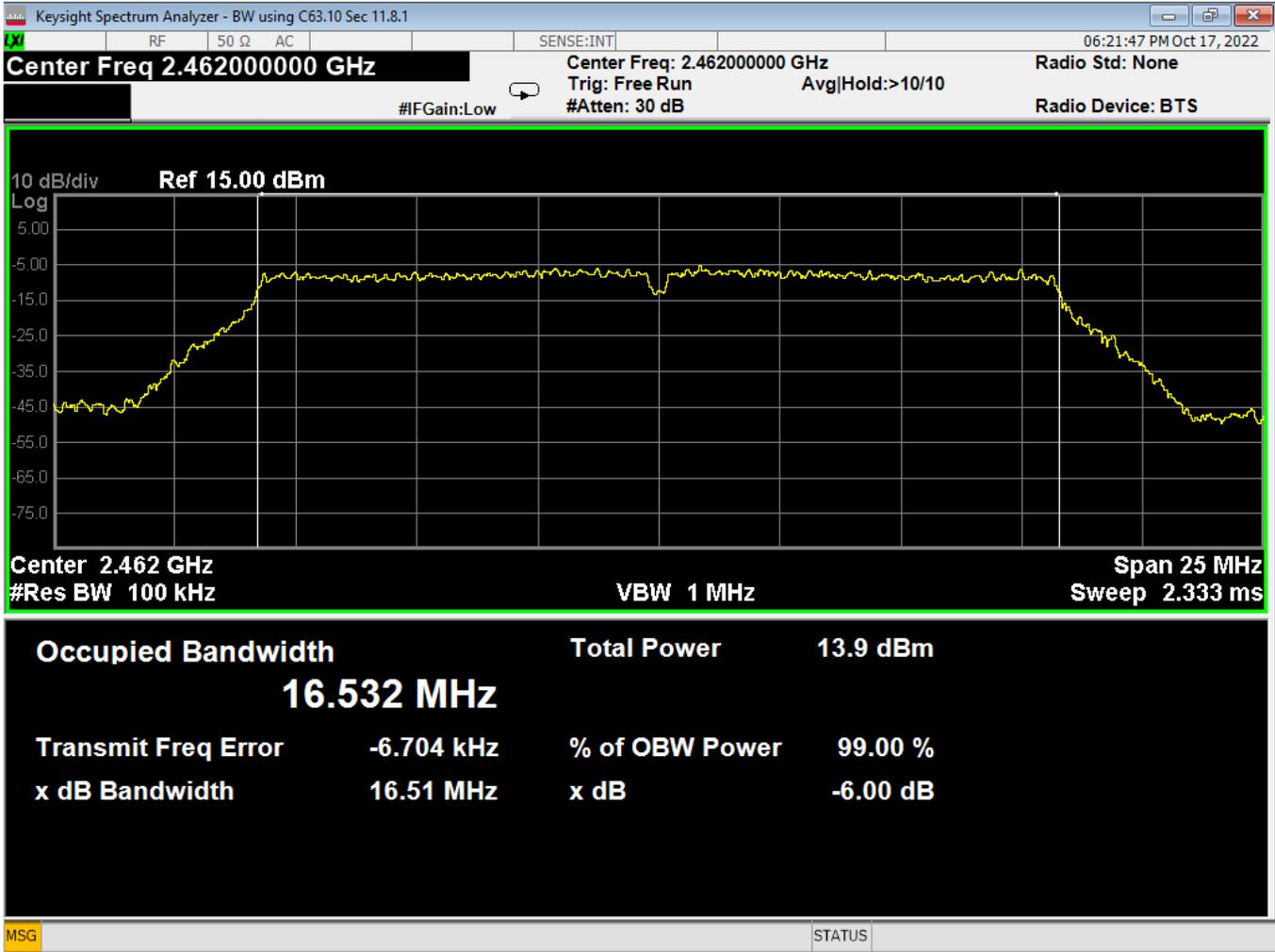
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



18 6dB Bandwidth, Mid, Wifi G, Low Data Rate



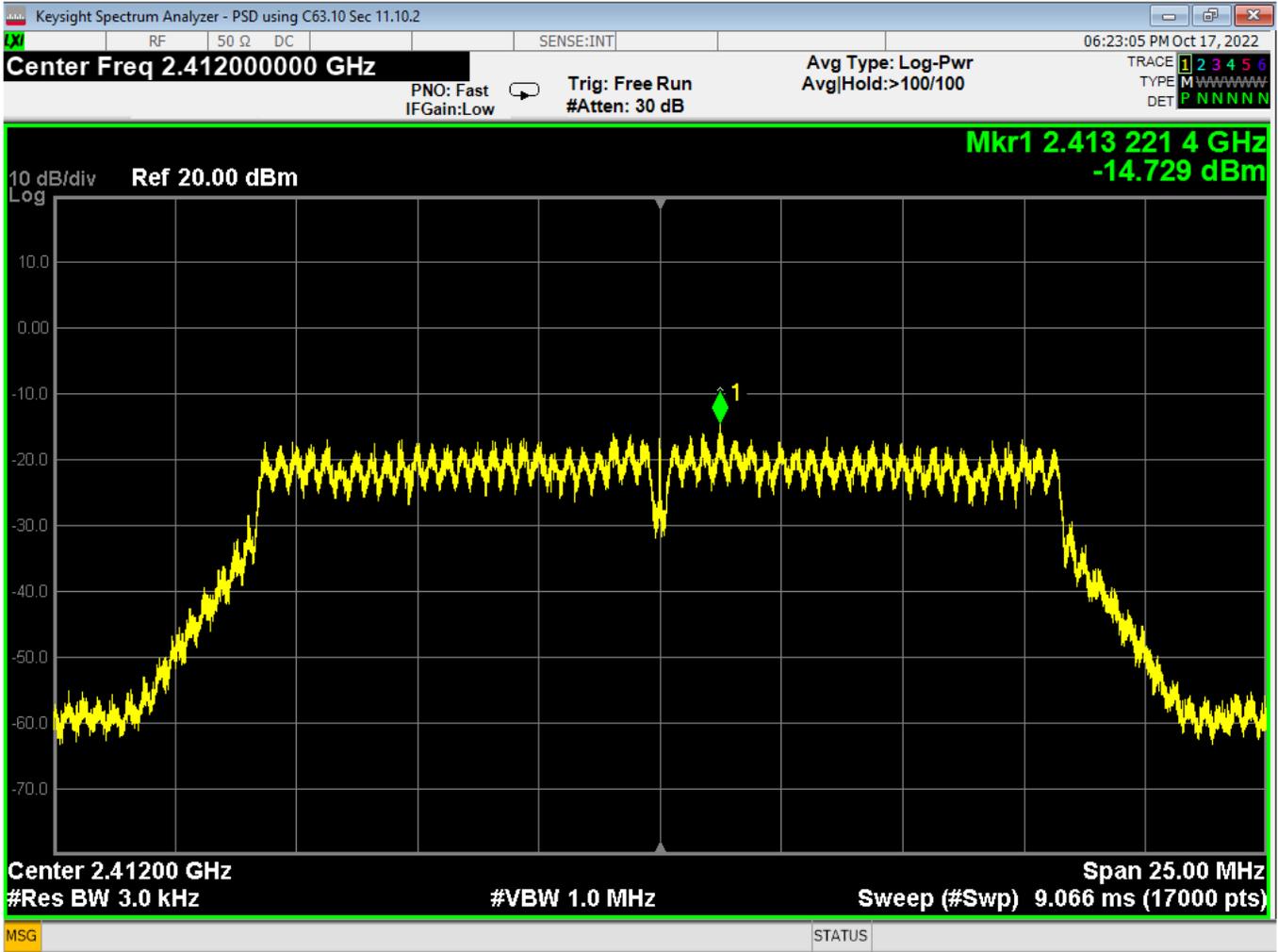
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



19 6dB Bandwidth, High, Wifi G, Low Data Rate



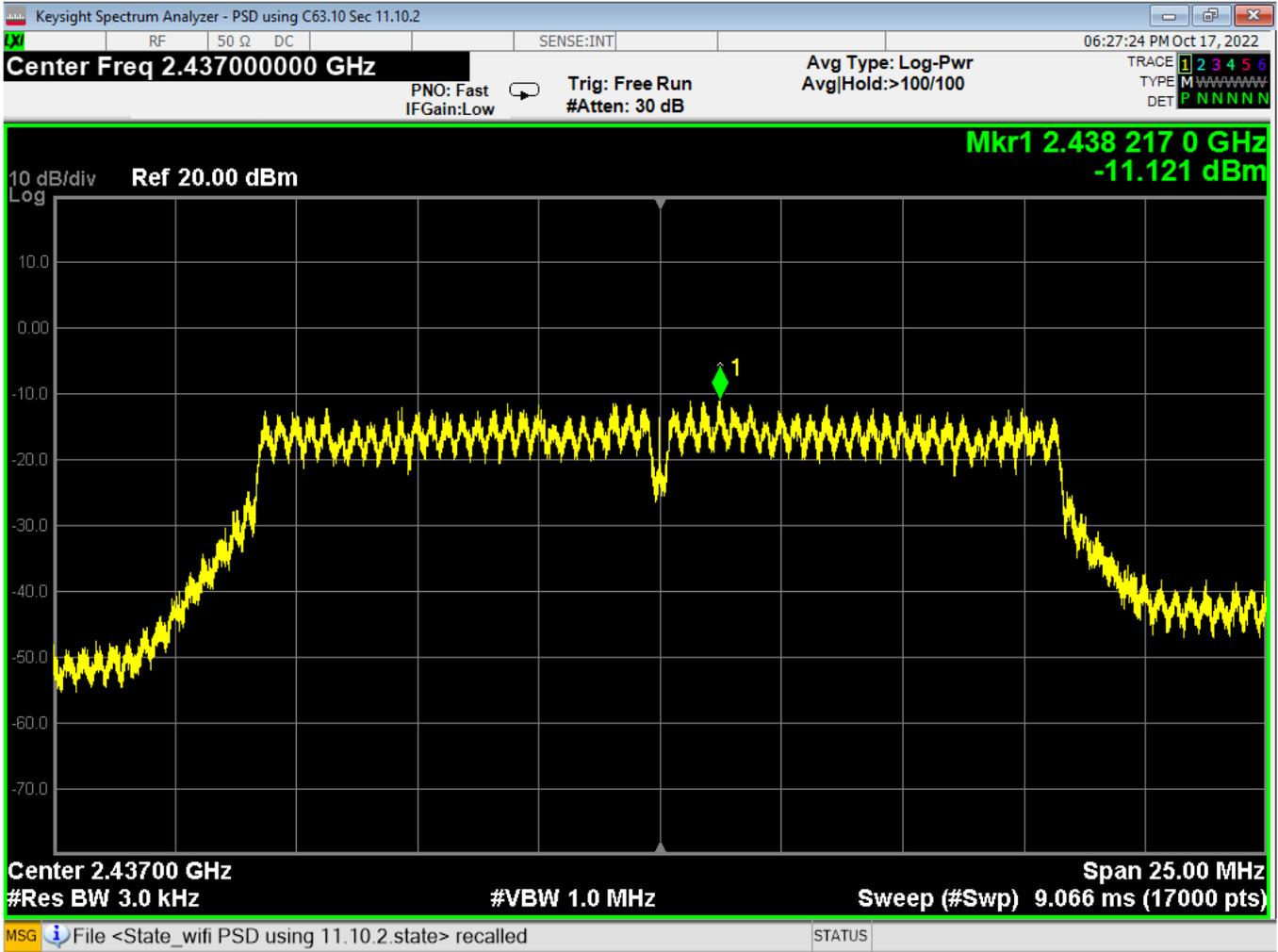
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



20 PSD, Low, Wifi G, Low Data Rate



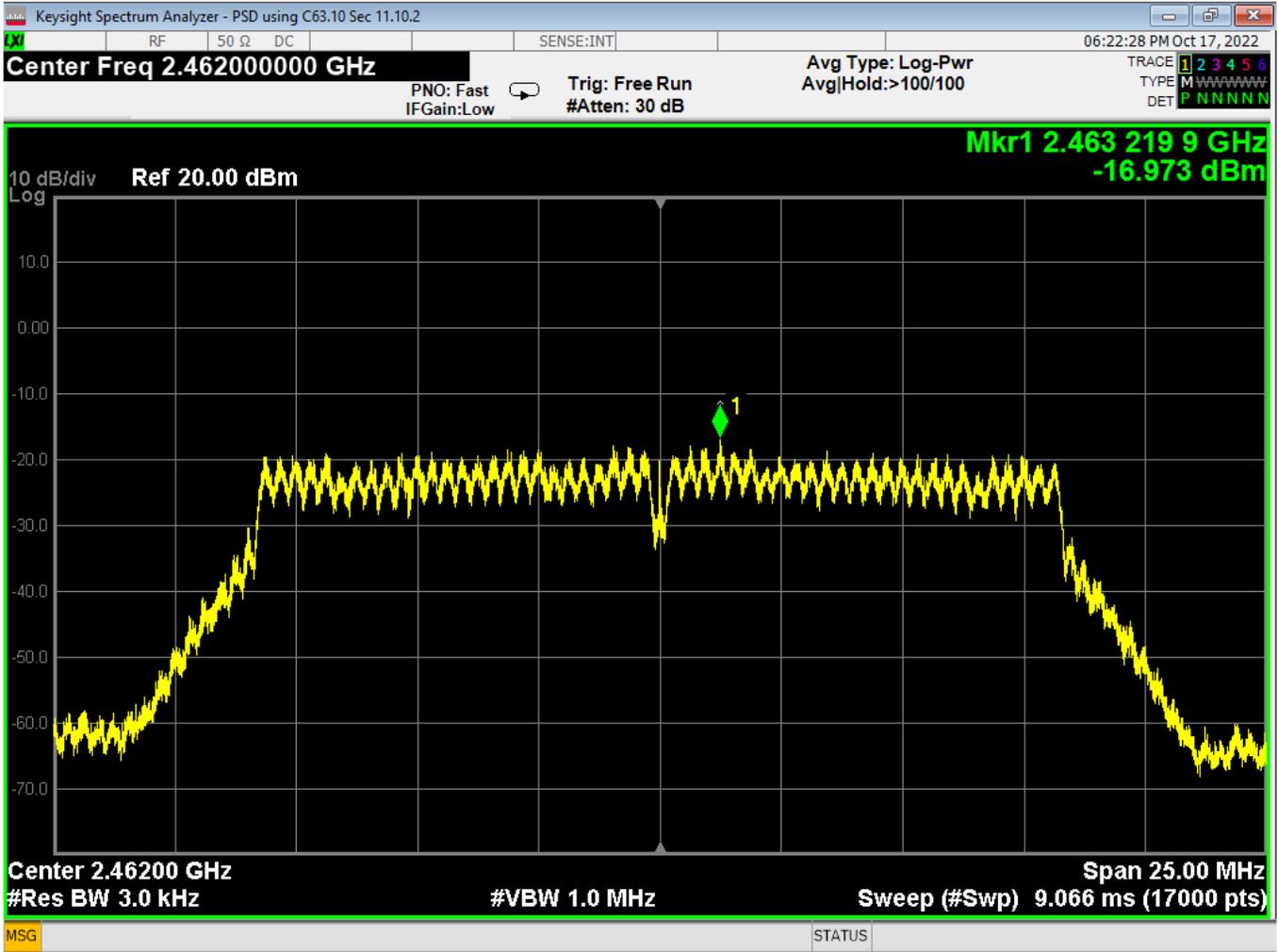
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



21 PSD, Mid, Wifi G, Low Data Rate



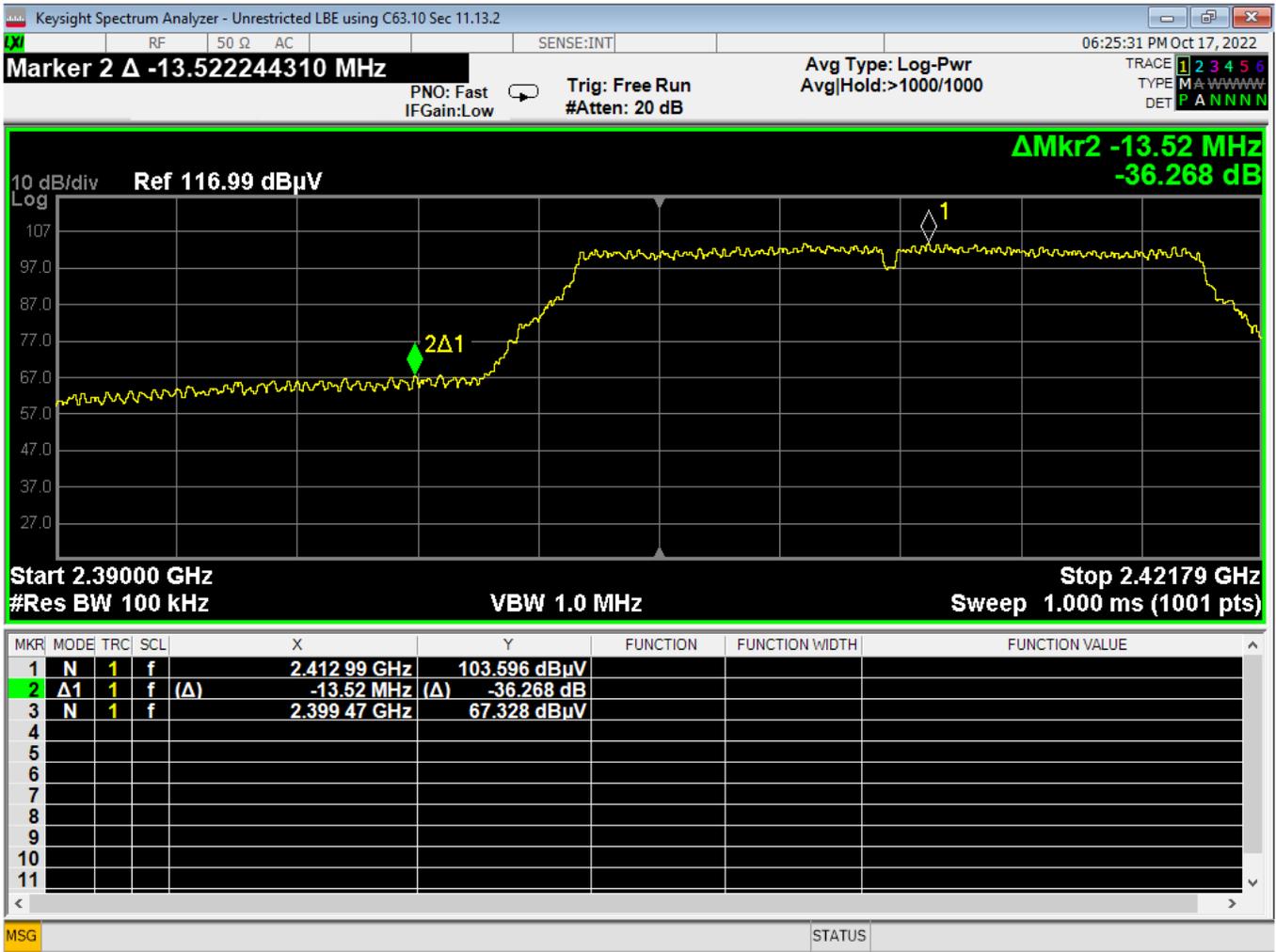
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



22 PSD, High, Wifi G, Low Data Rate



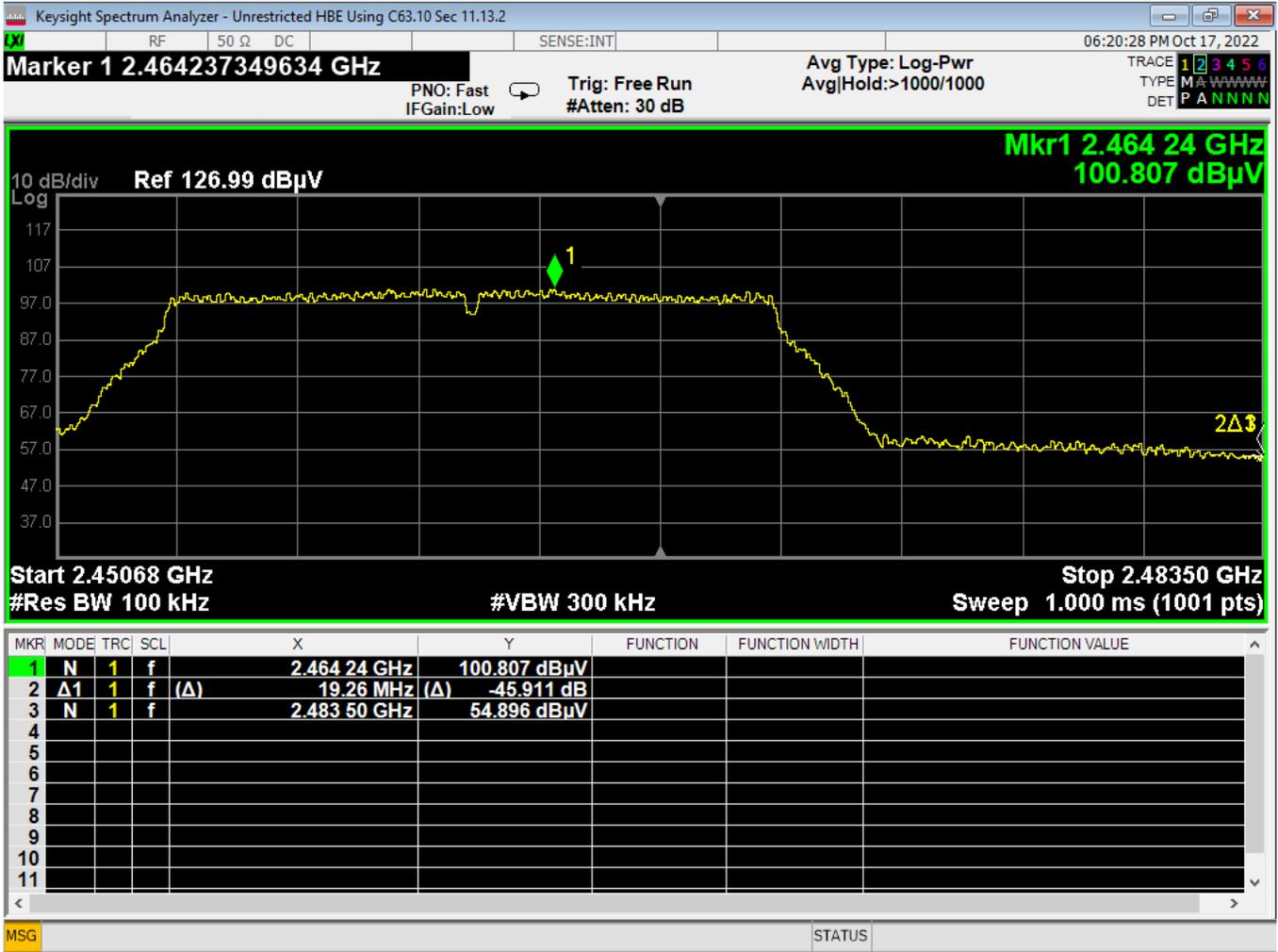
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



23 Lower Bandedge, Unrestricted, Wifi G, Low Data Rate



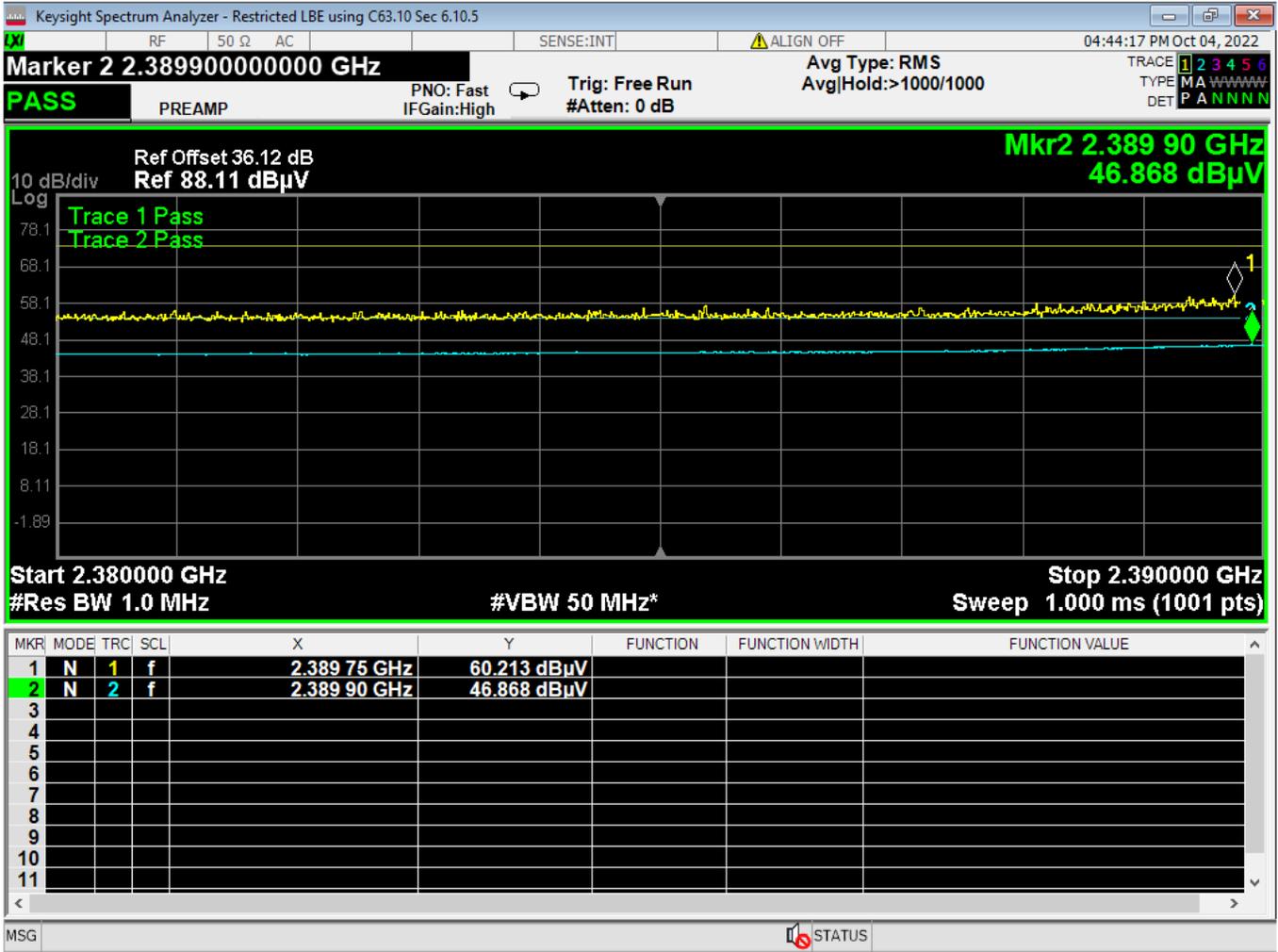
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



24 Higher Bandedge, Unrestricted, Wifi G, Low Data Rate



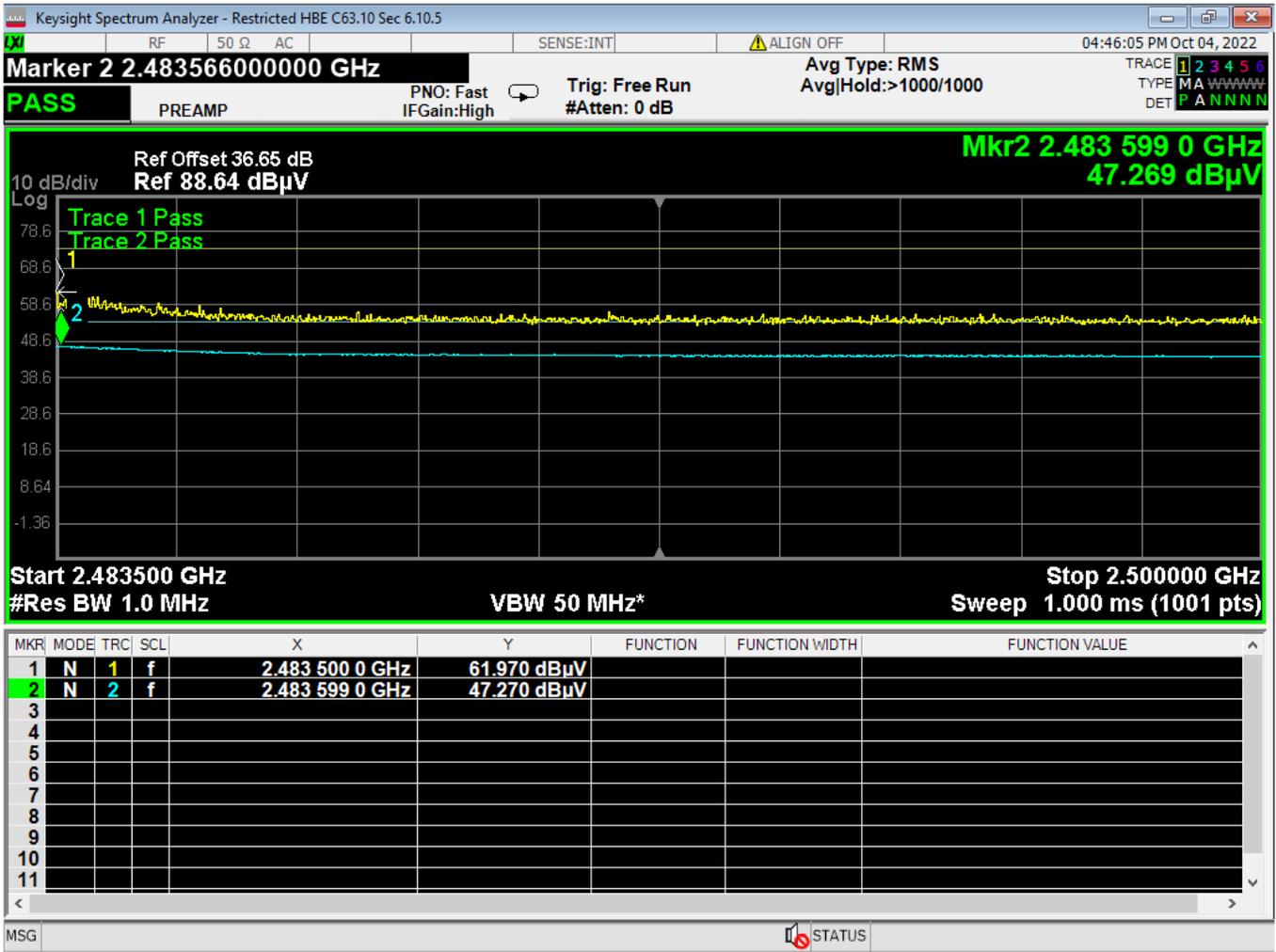
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



25 Lower Bandedge, Restricted, Wifi G, Low Data Rate



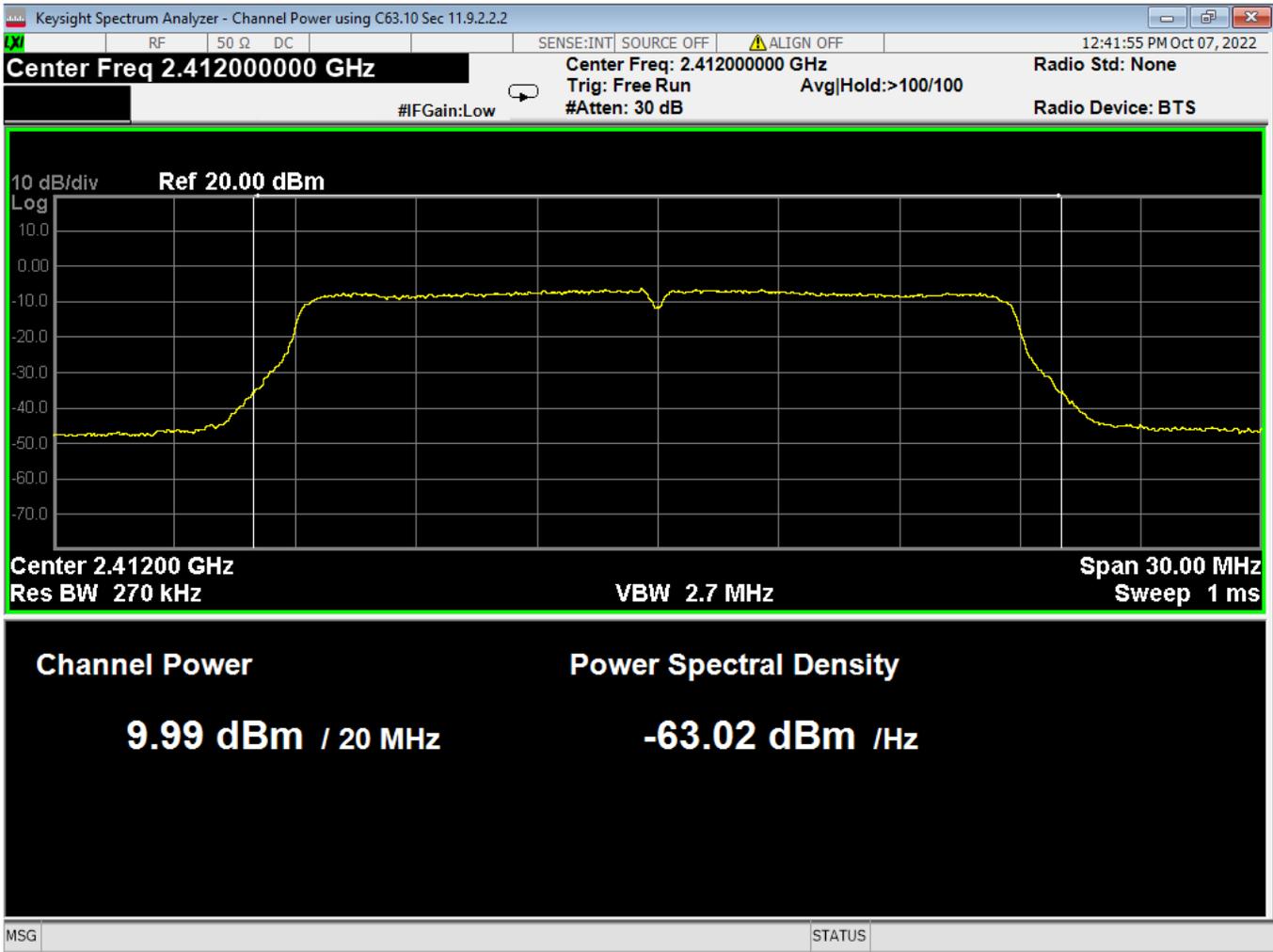
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



26 Higher Bandedge, Restricted, Wifi G, Low Data Rate



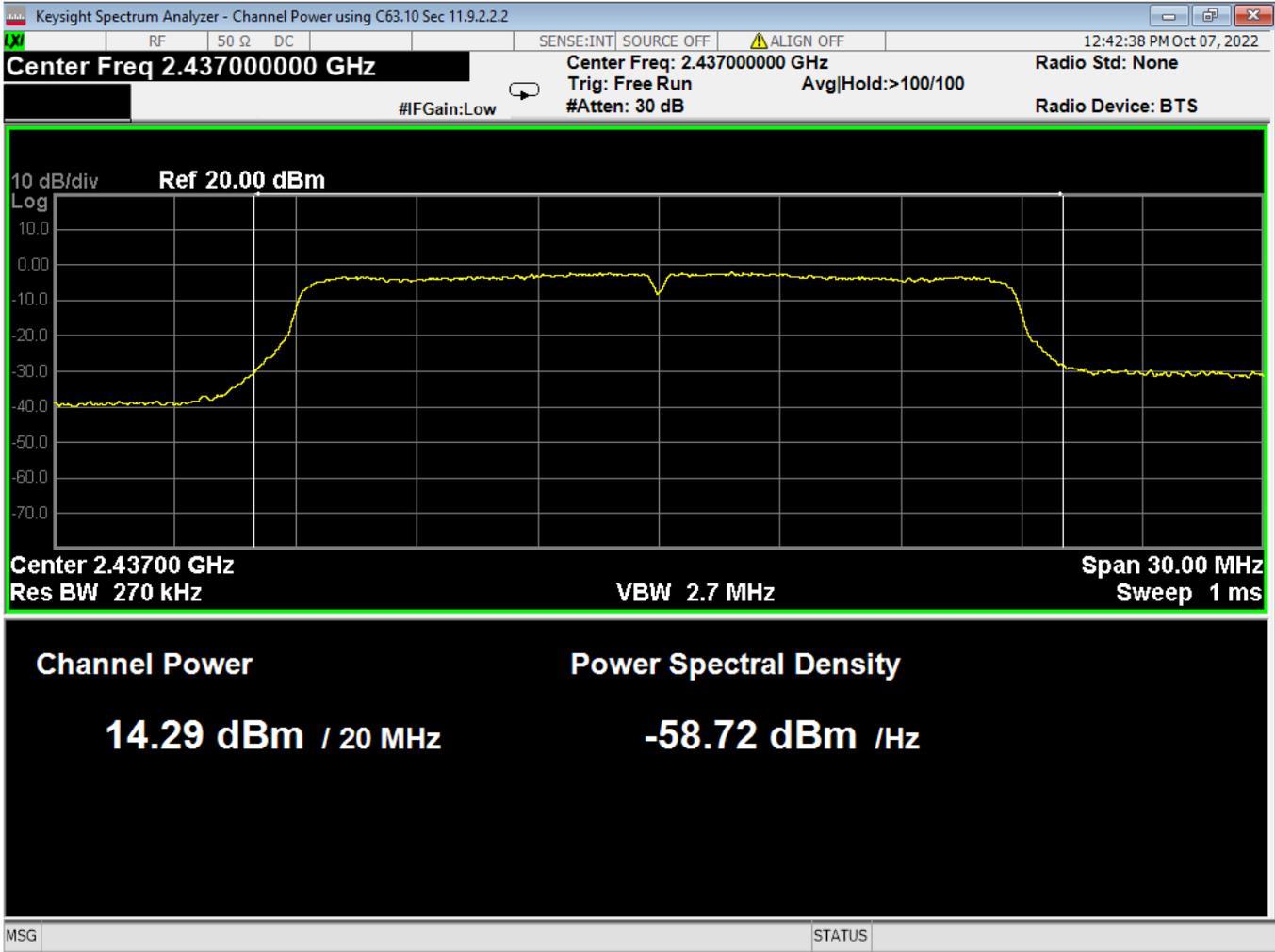
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



27 Average Power, Low, Wifi N, Low Data Rate



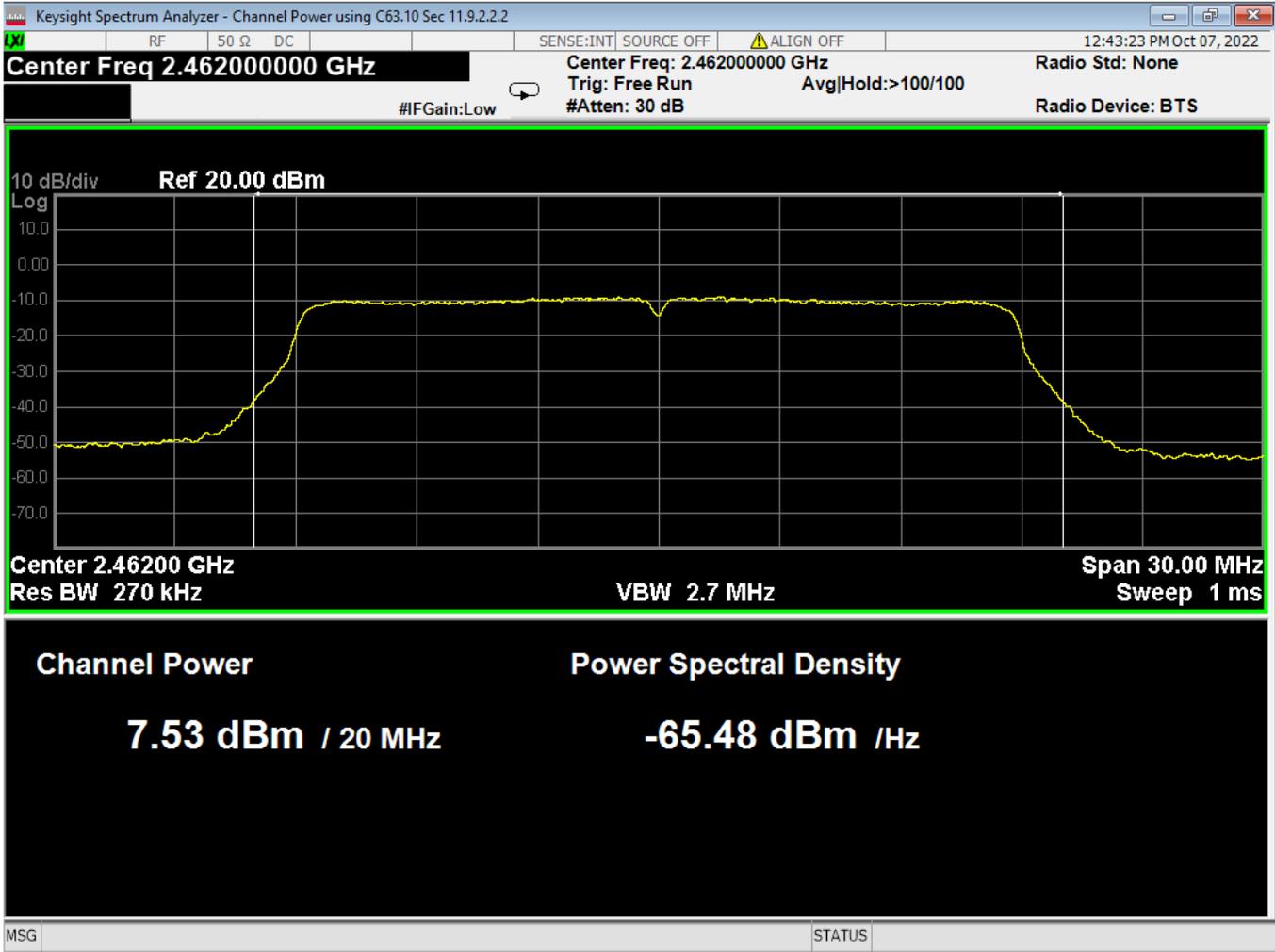
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



28 Average Power, Mid, Wifi N, Low Data Rate



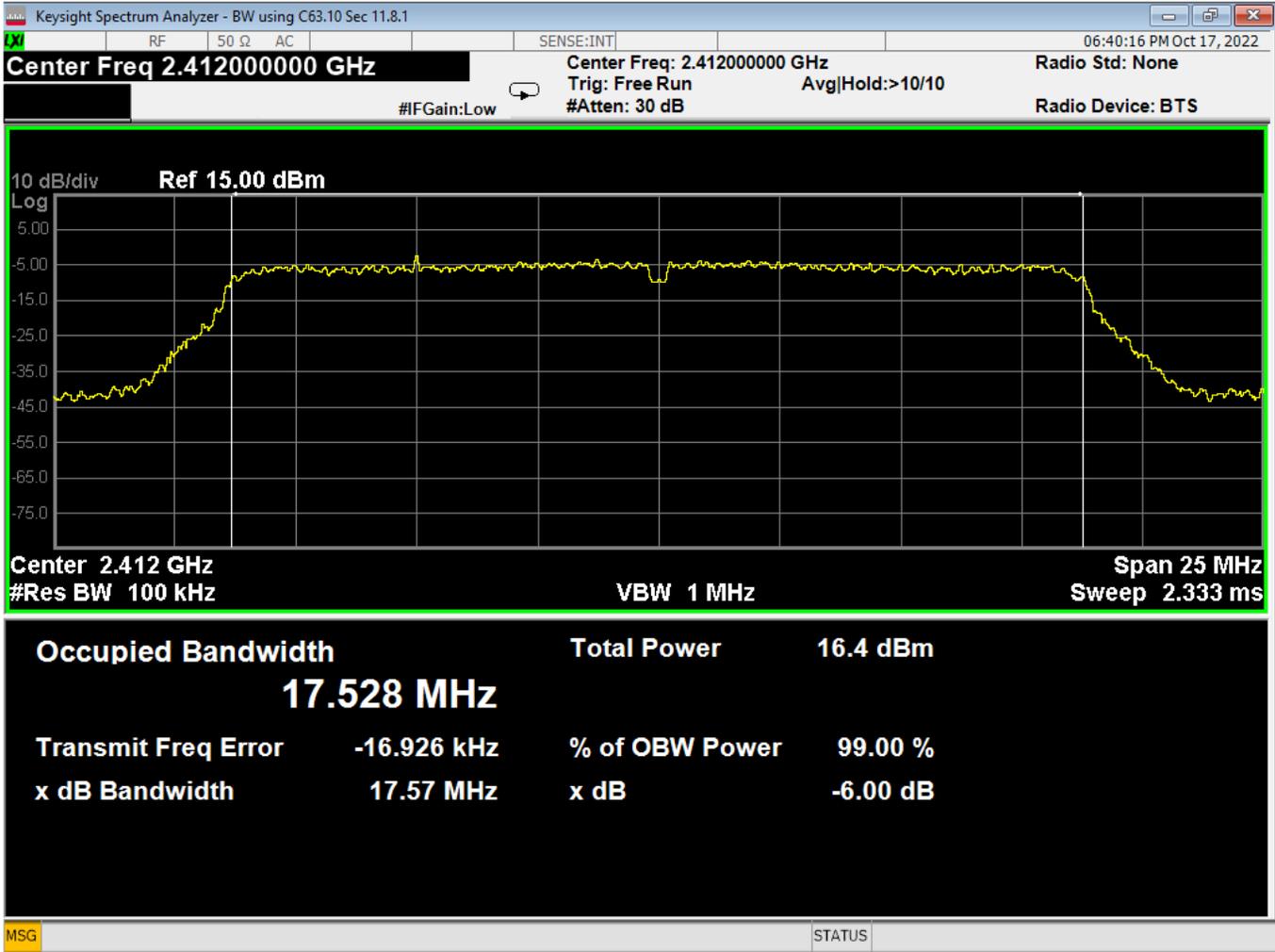
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



29 Average Power, High, Wifi N, Low Data Rate



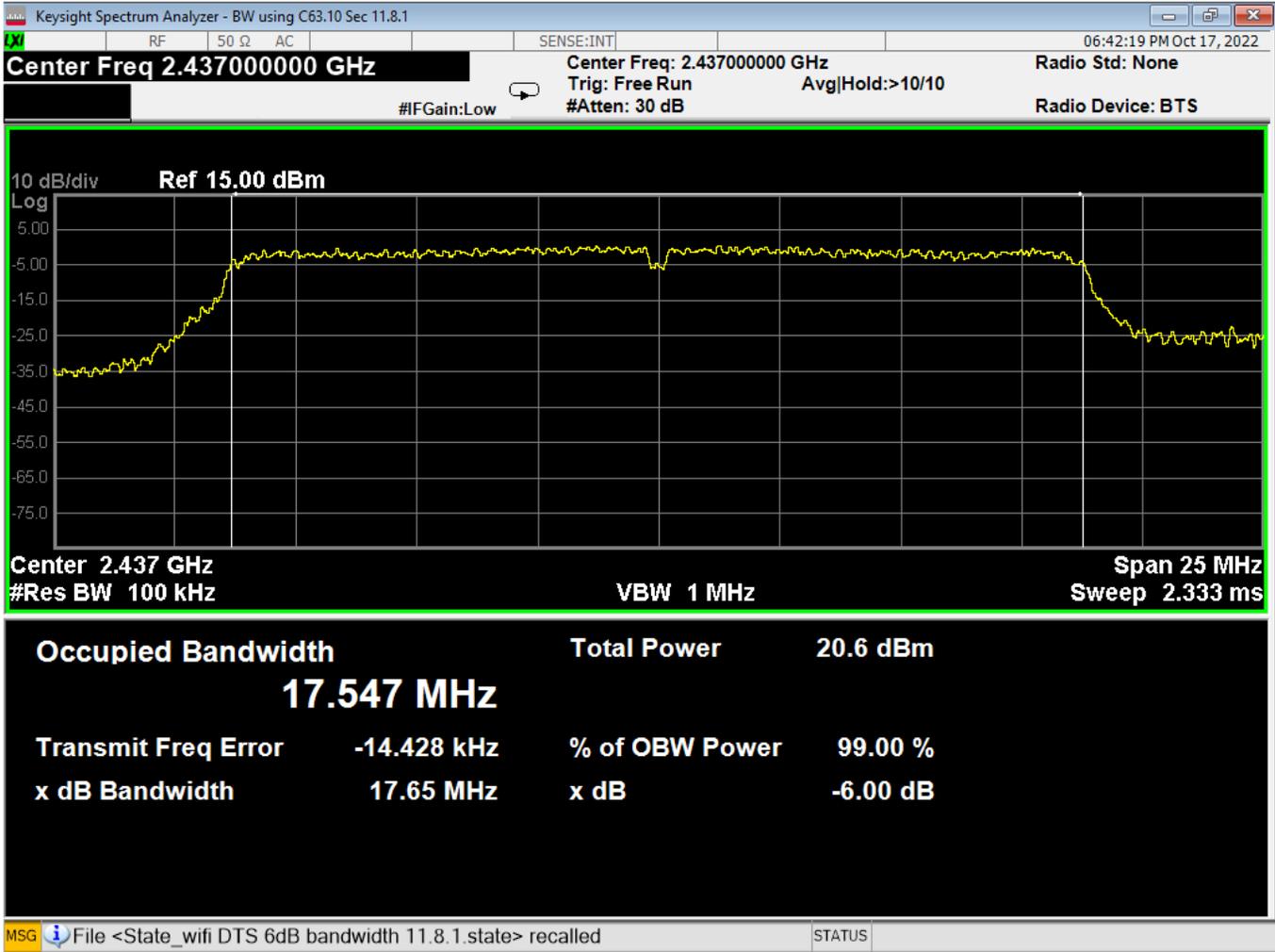
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



30 6dB Bandwidth, Low, Wifi N, Low Data Rate



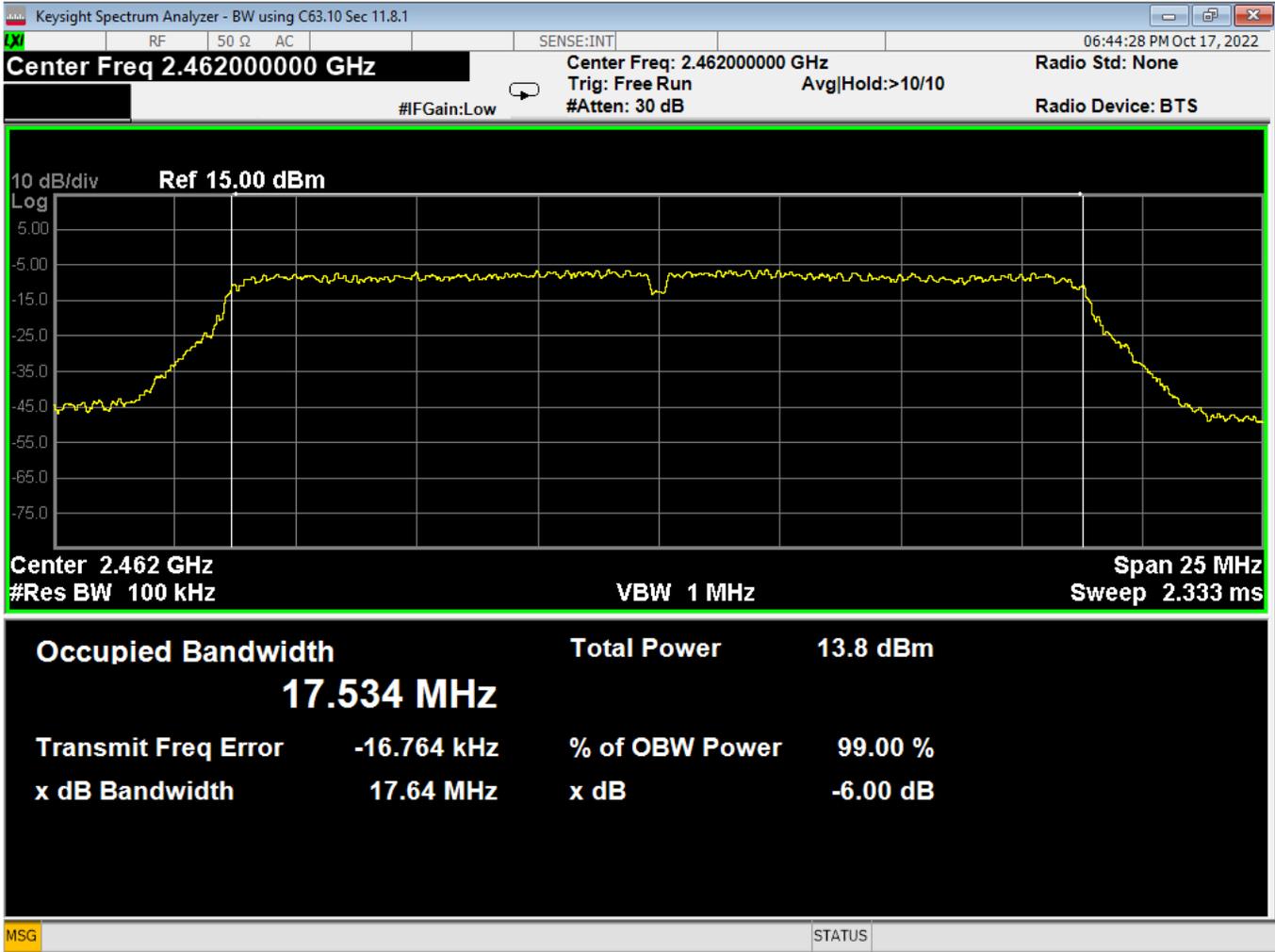
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



31 6dB Bandwidth, Mid, Wifi N, Low Data Rate



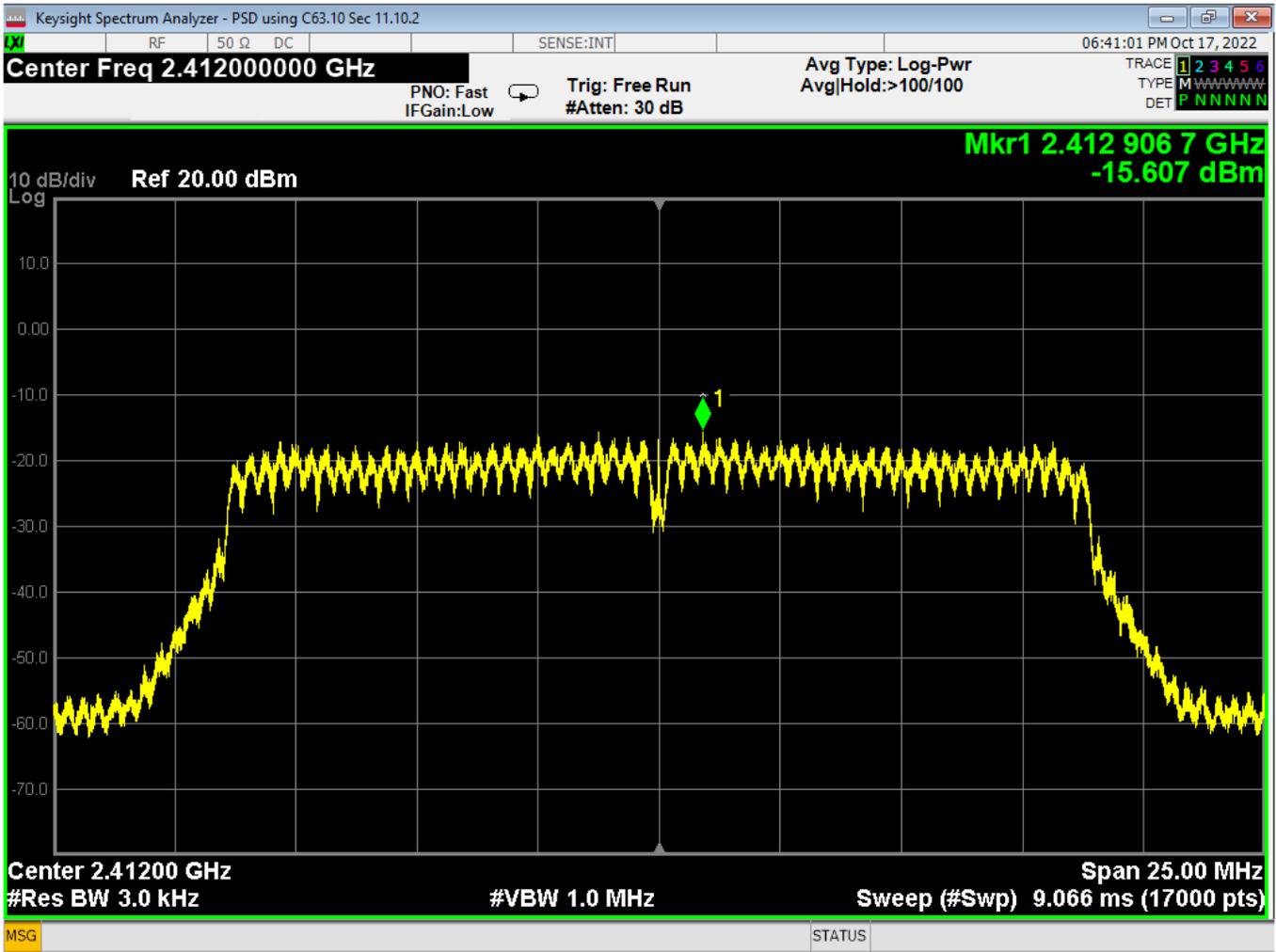
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



32 6dB Bandwidth, High, Wifi N, Low Data Rate



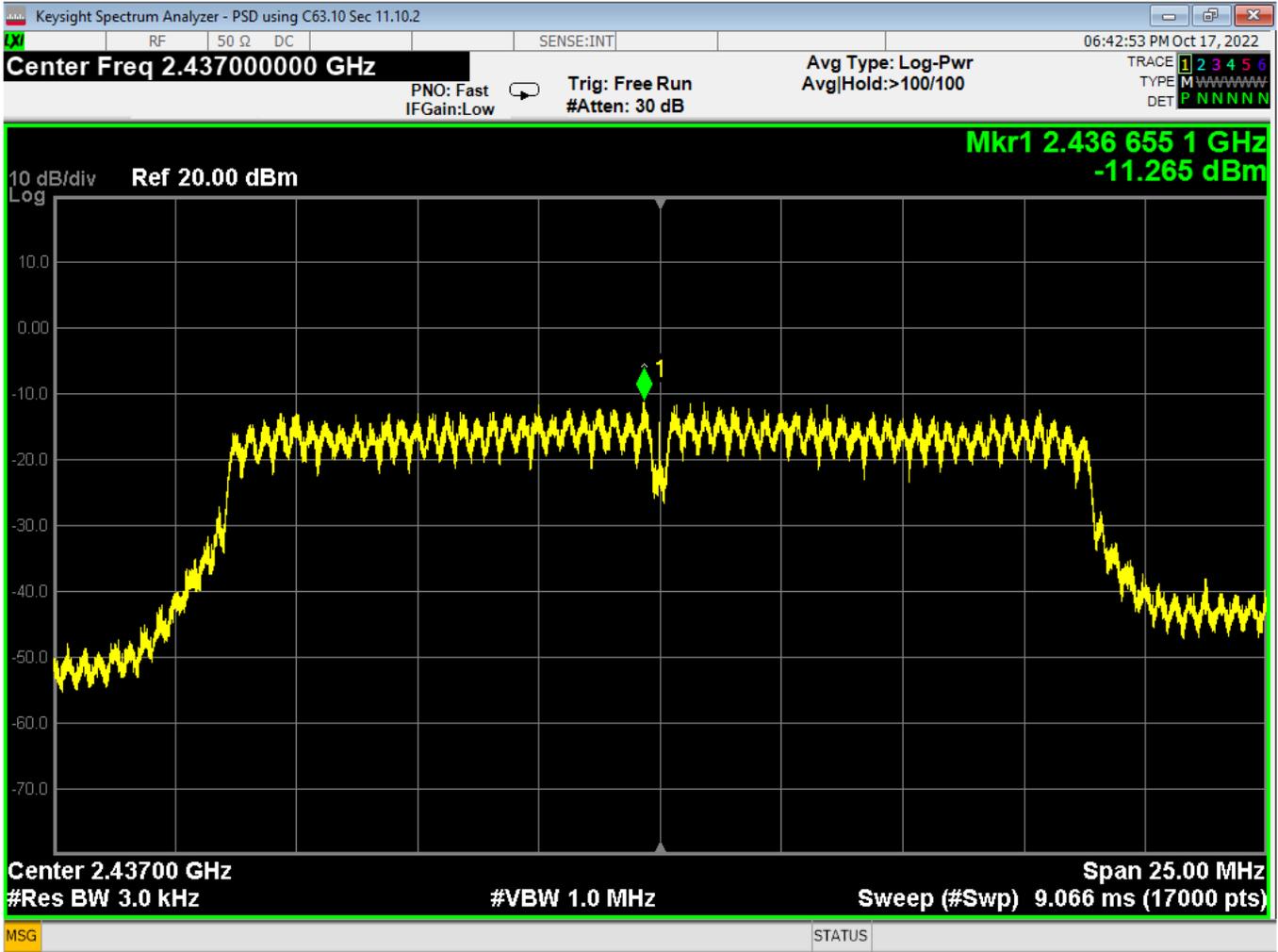
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



33 PSD, Low, Wifi N, Low Data Rate



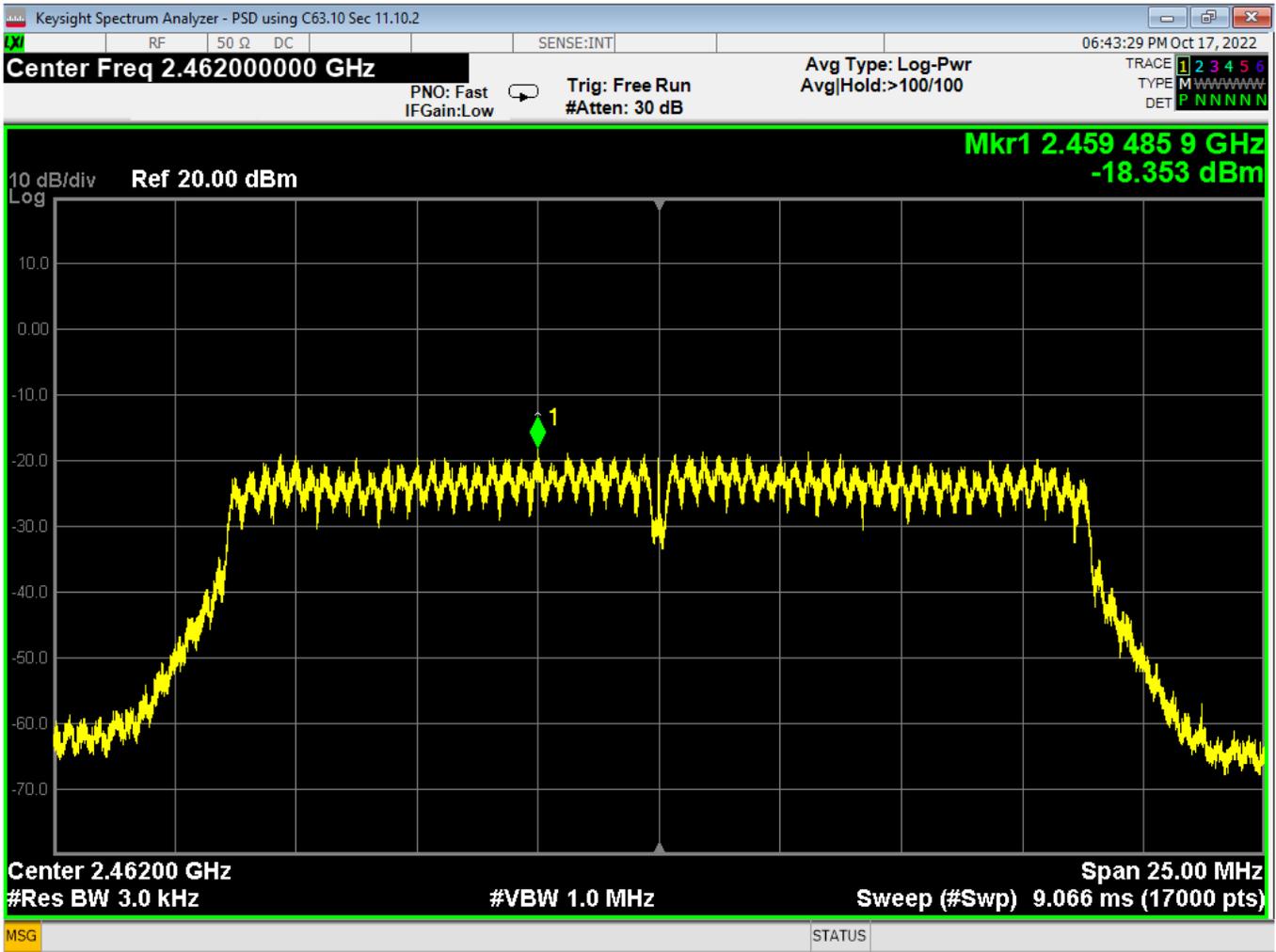
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



34 PSD, Mid, Wifi N, Low Data Rate



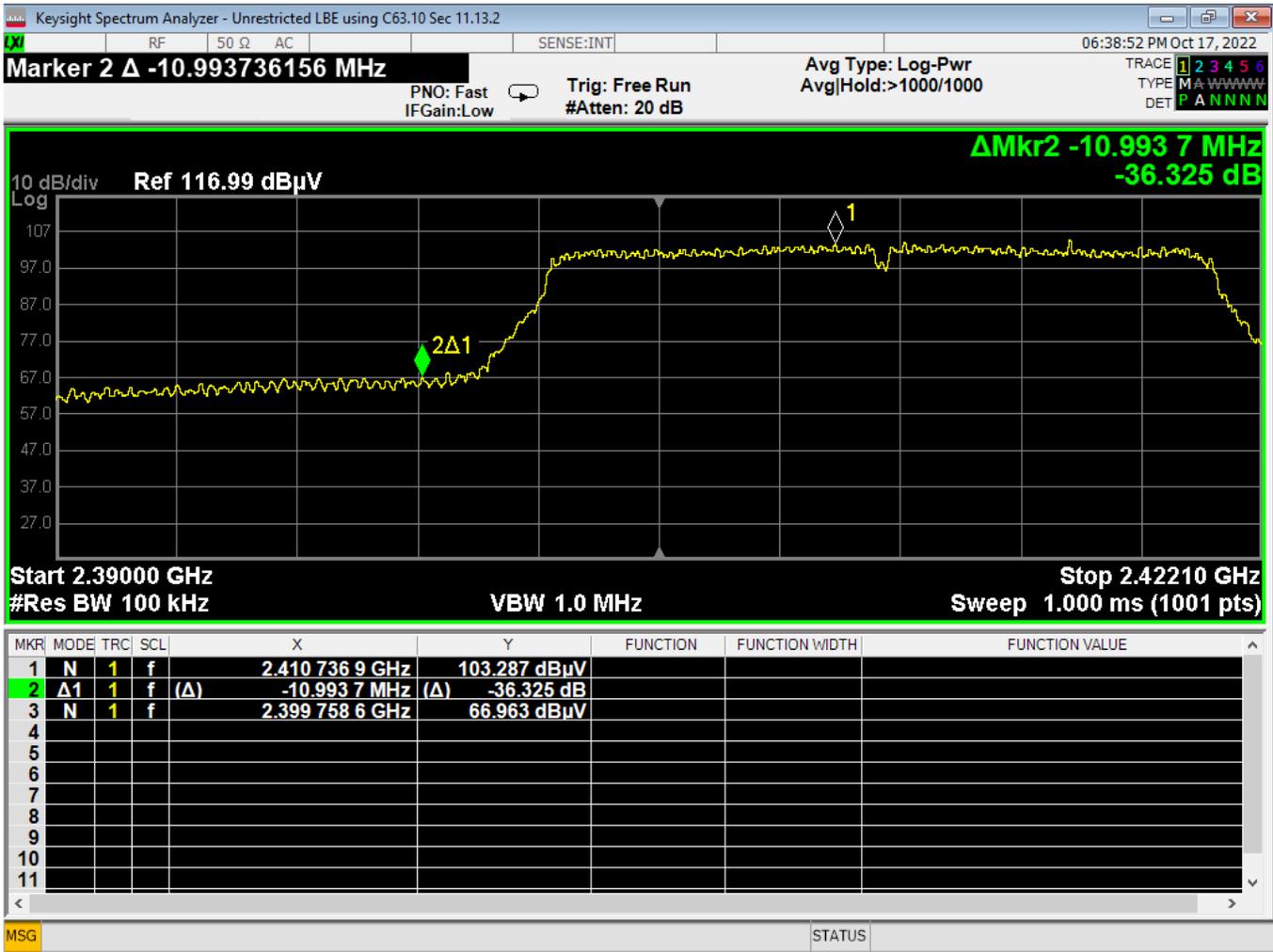
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



35 PSD, High, Wifi N, Low Data Rate



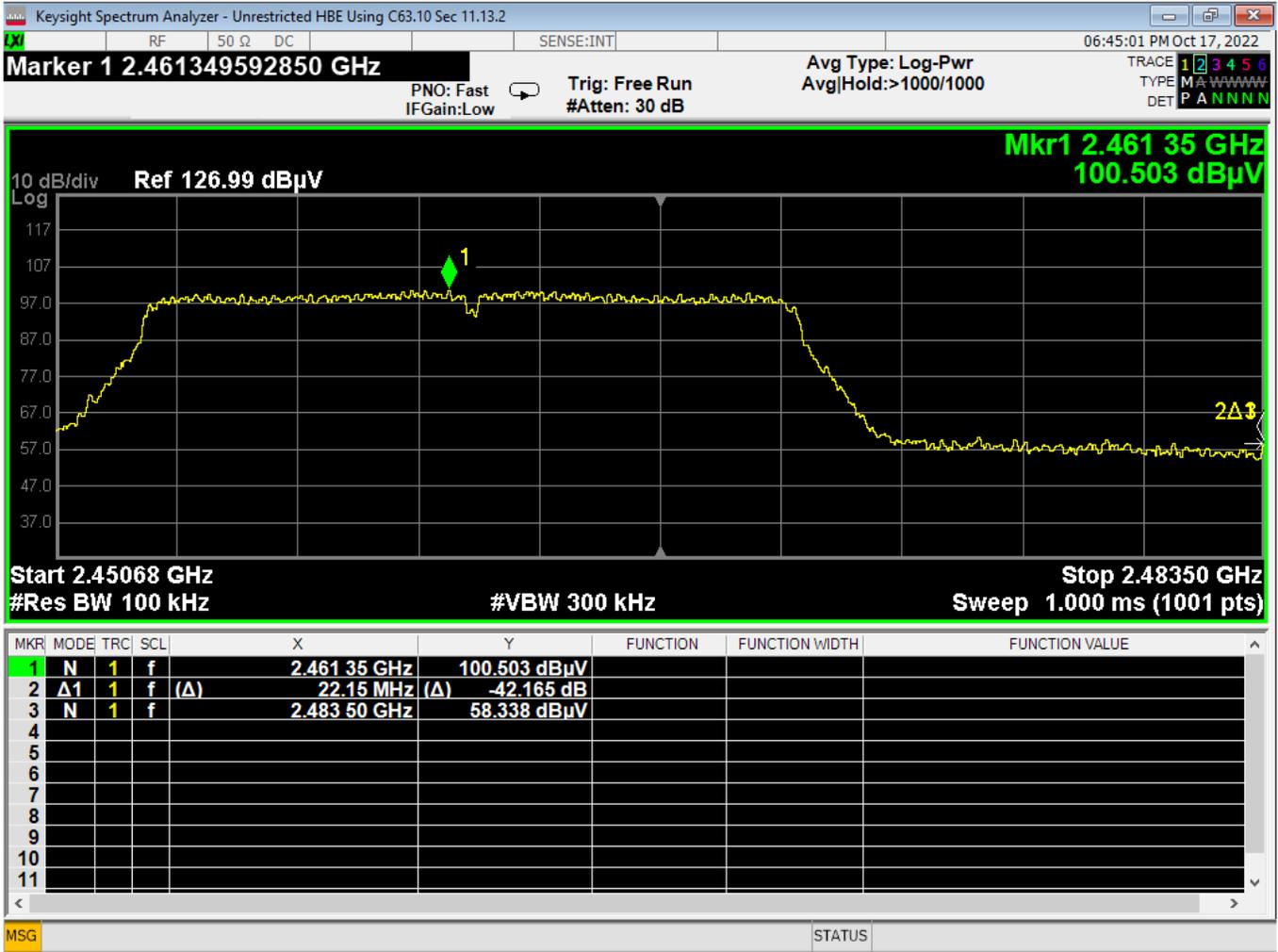
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



36 Lower Bandedge, Unrestricted, Wifi N, Low Data Rate



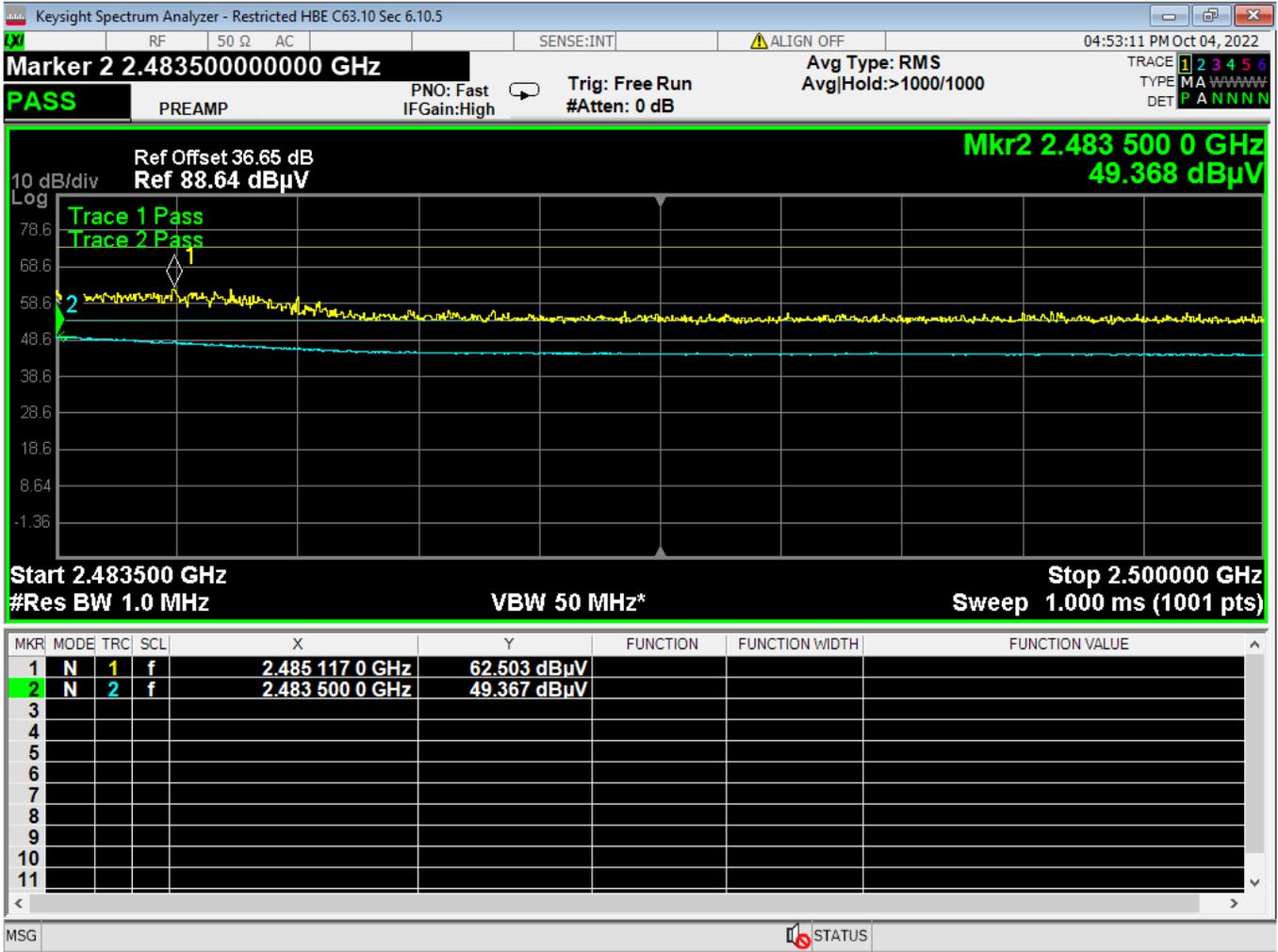
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



37 Higher Bandedge, Unrestricted, Wifi N, Low Data Rate



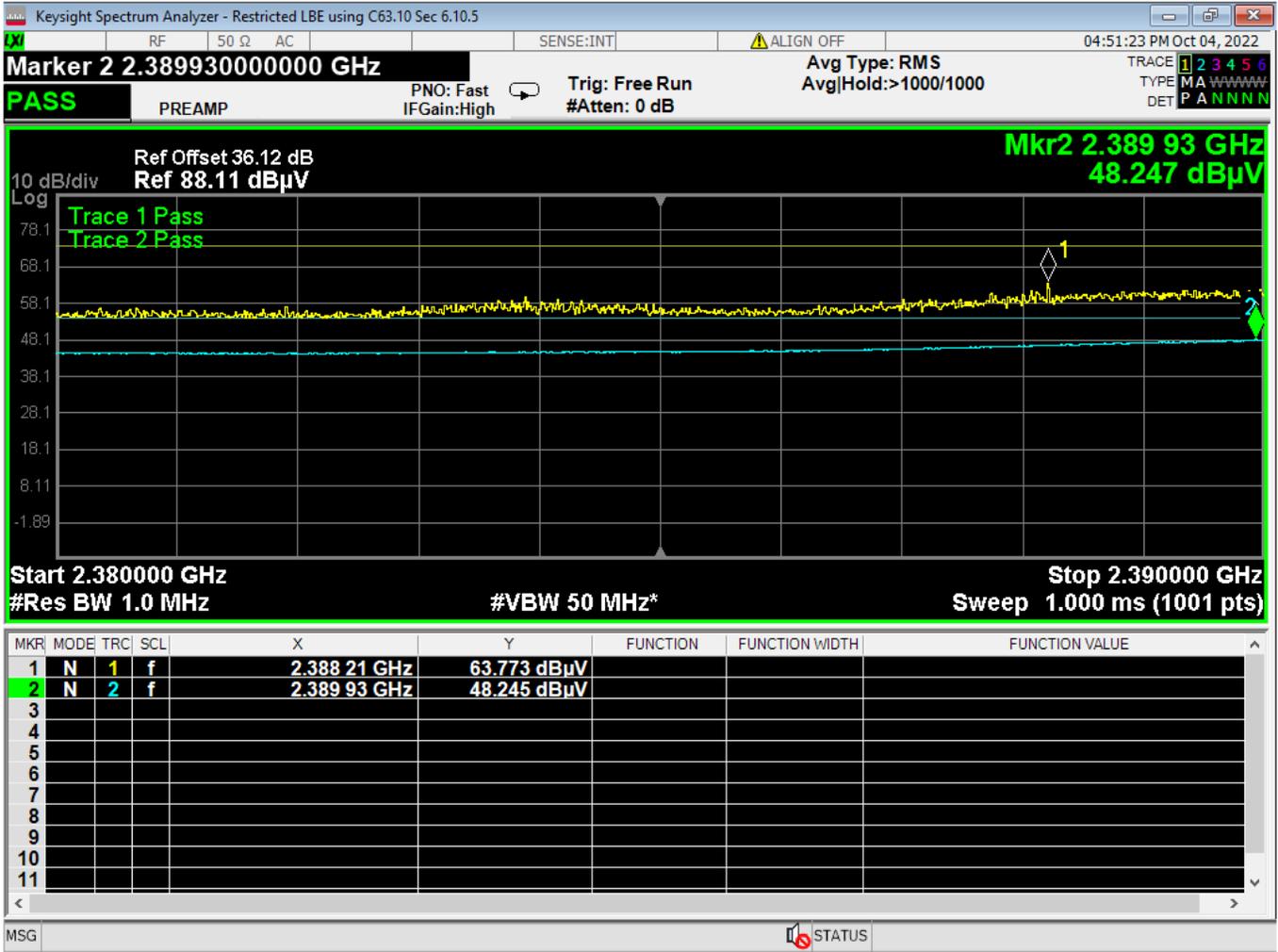
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



38 Lower Bandedge, Restricted, Wifi N, Low Data Rate



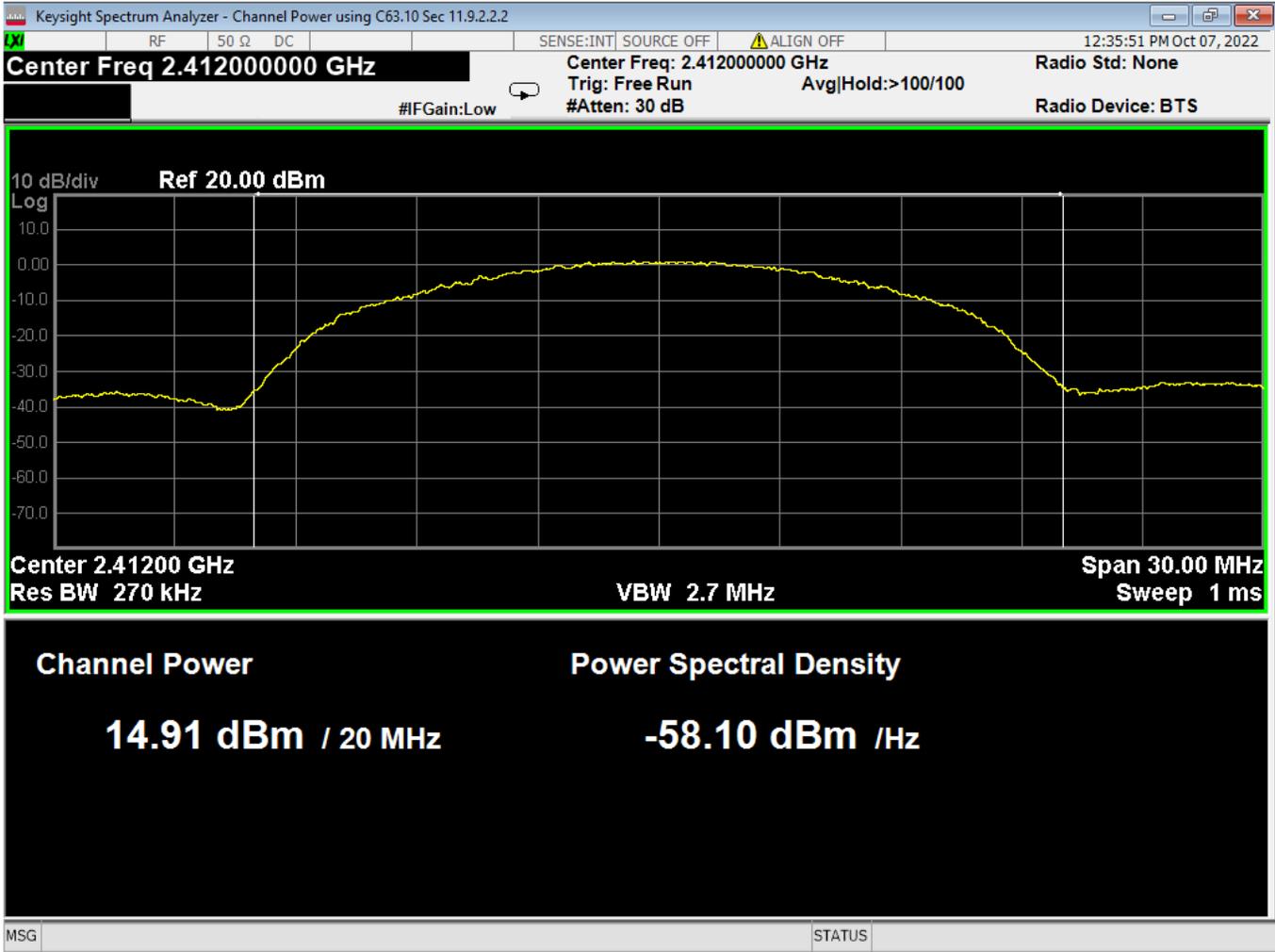
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



39 Higher Bandedge, Restricted, Wifi N, Low Data Rate



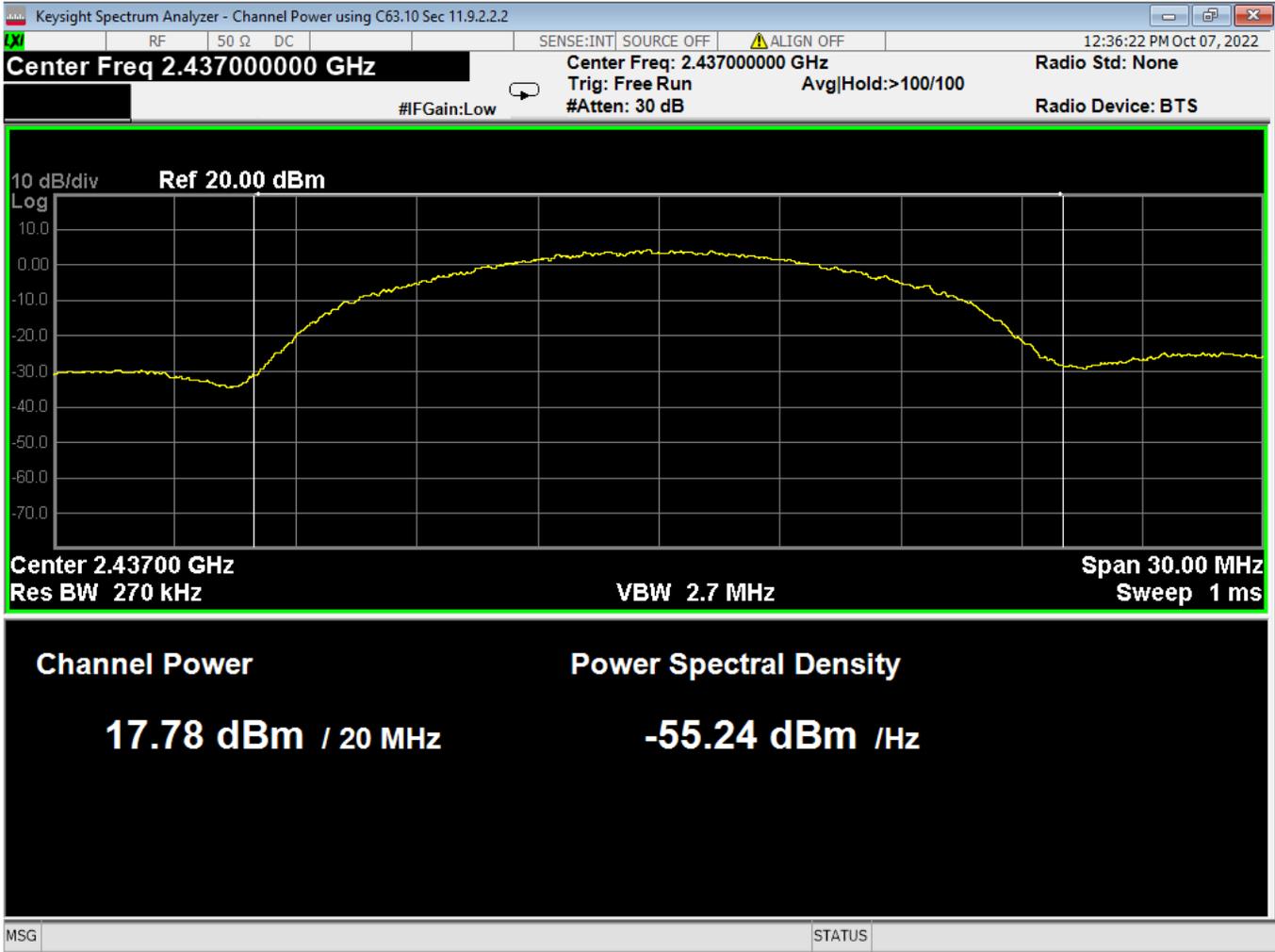
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



40 Average Power, Low, Wifi B, High Data Rate



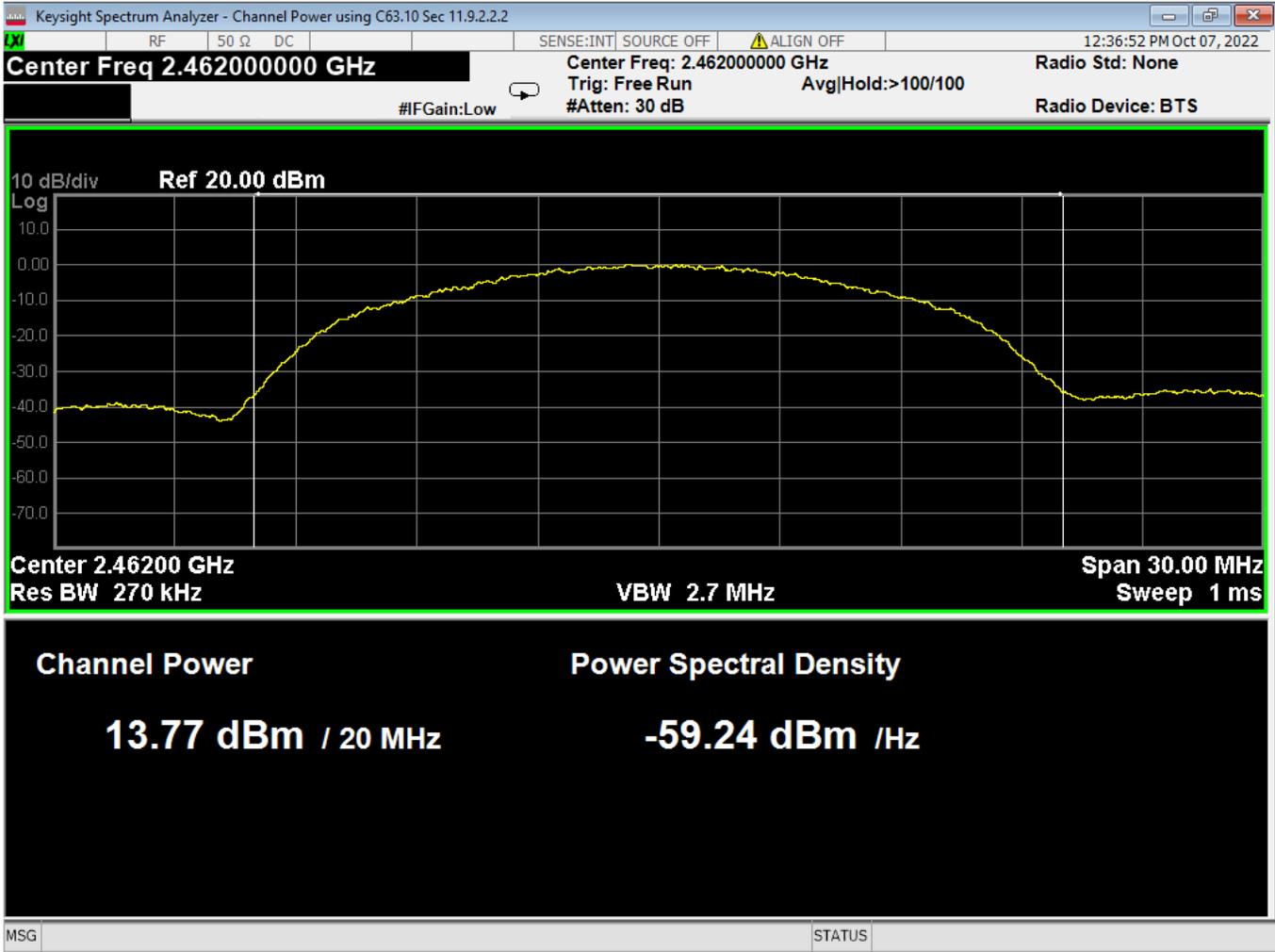
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



41 Average Power, Mid, Wifi B, High Data Rate



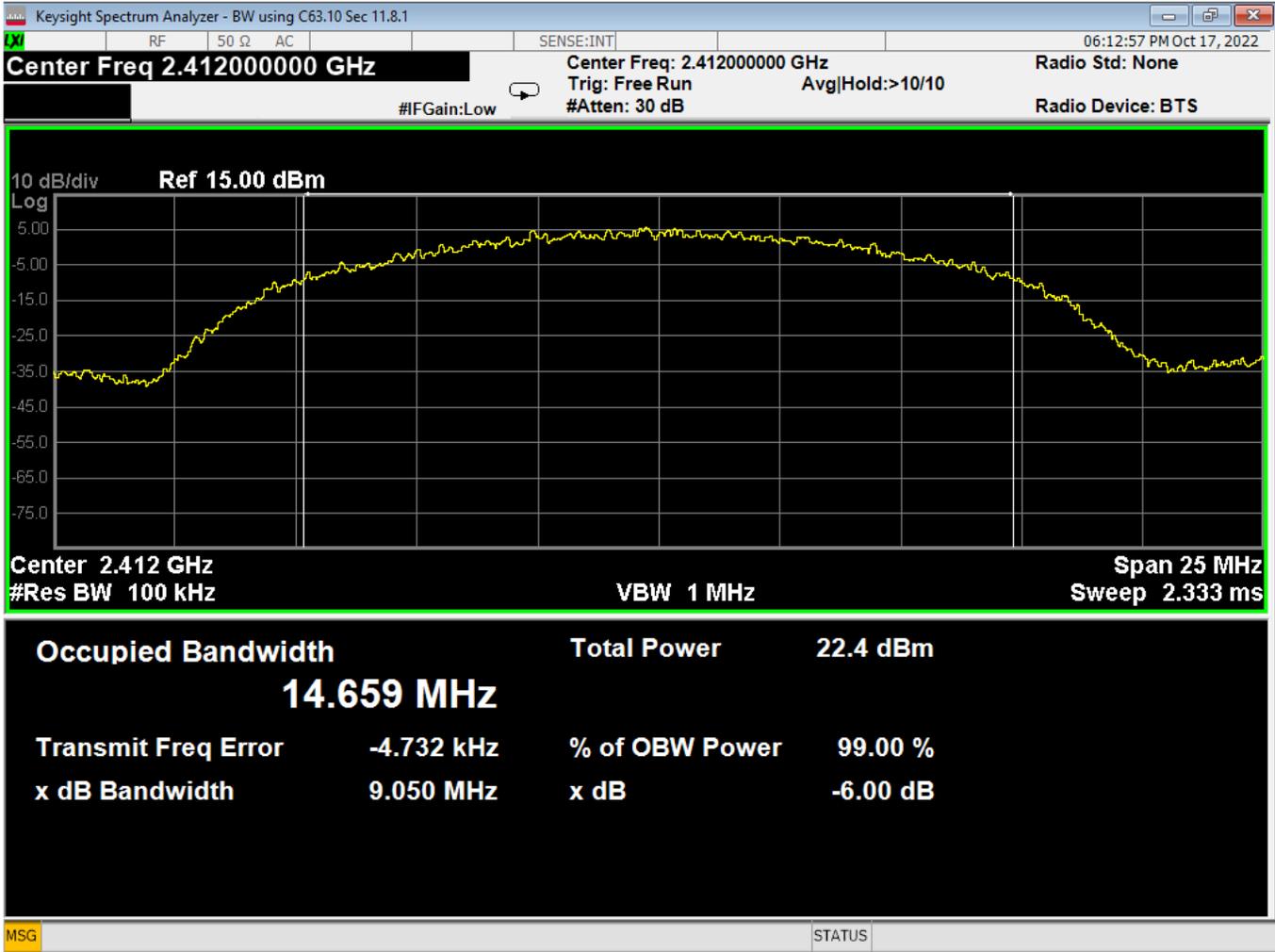
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



42 Average Power, High, Wifi B, High Data Rate



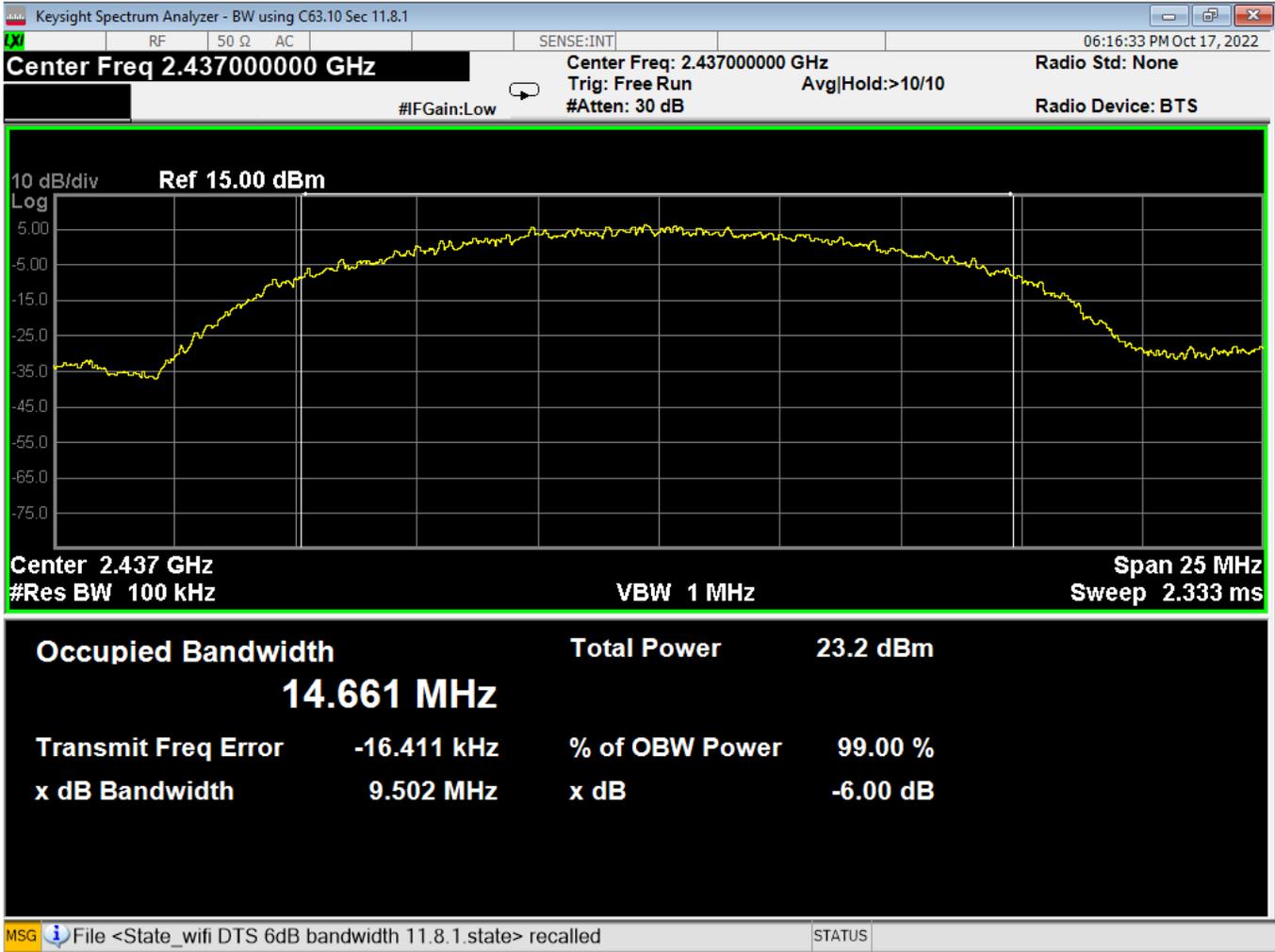
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



43 6dB Bandwidth, Low, Wifi B, High Data Rate



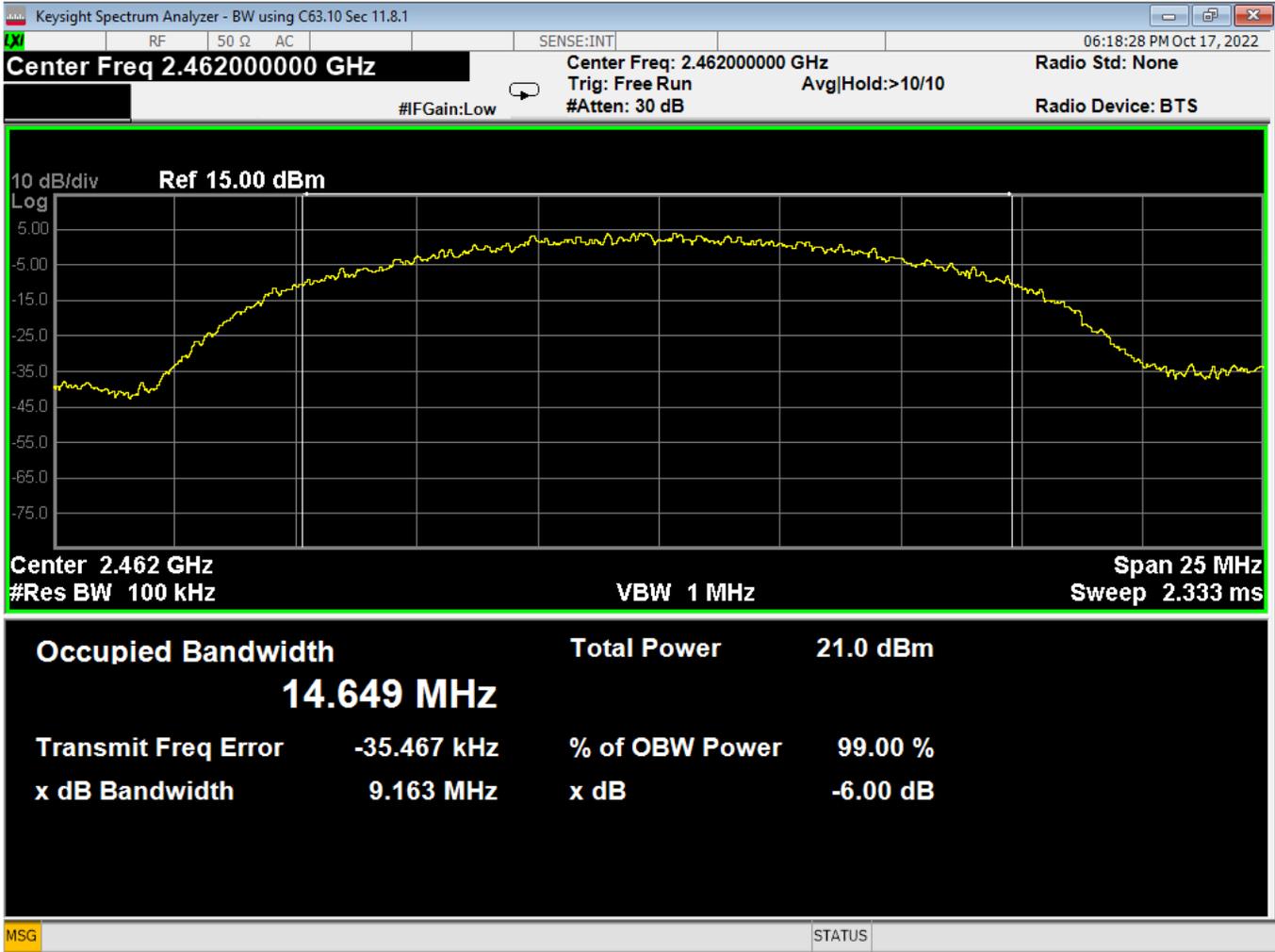
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



44 6dB Bandwidth, Mid, Wifi B, High Data Rate



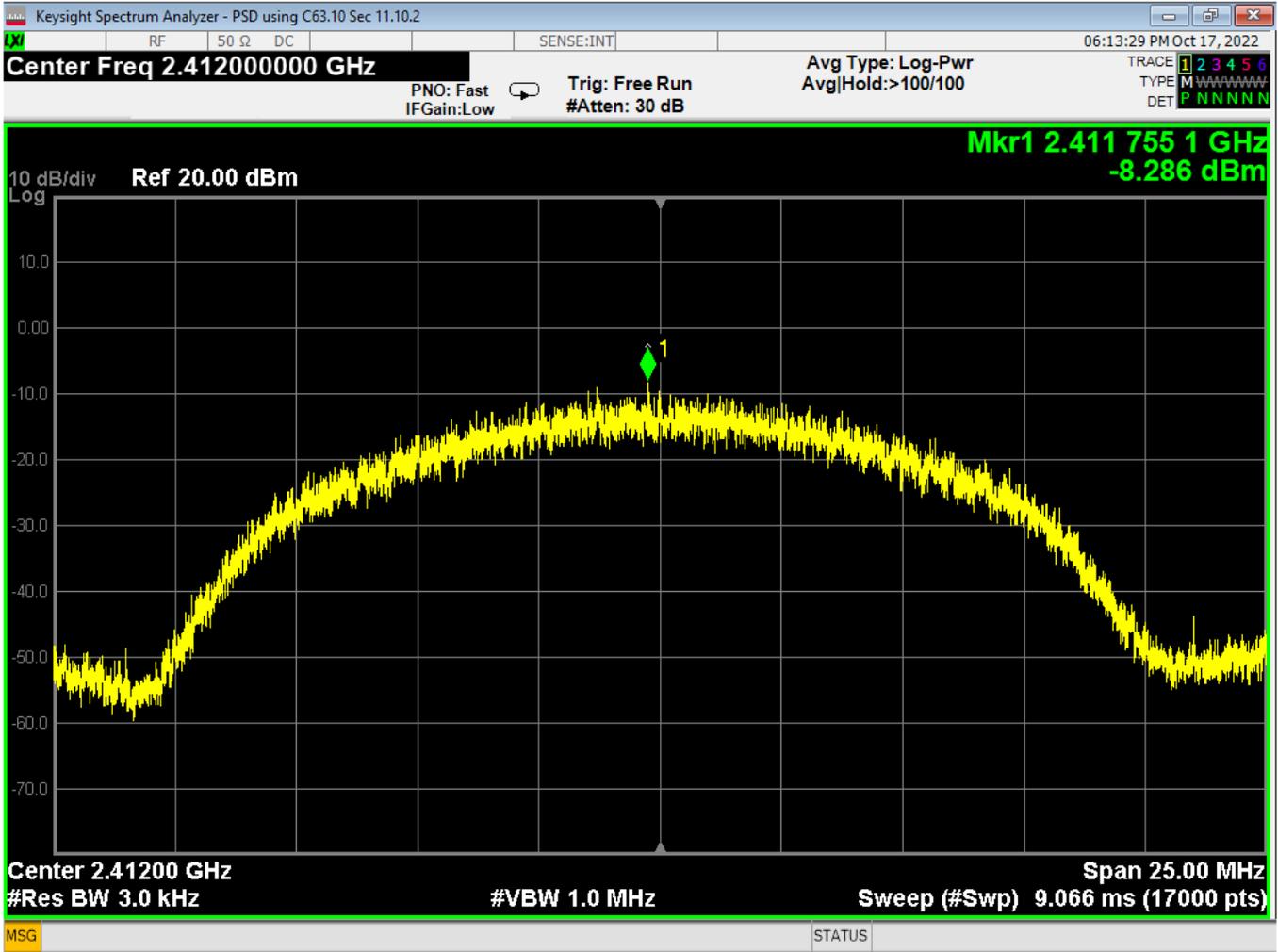
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



45 6dB Bandwidth, High, Wifi B, High Data Rate



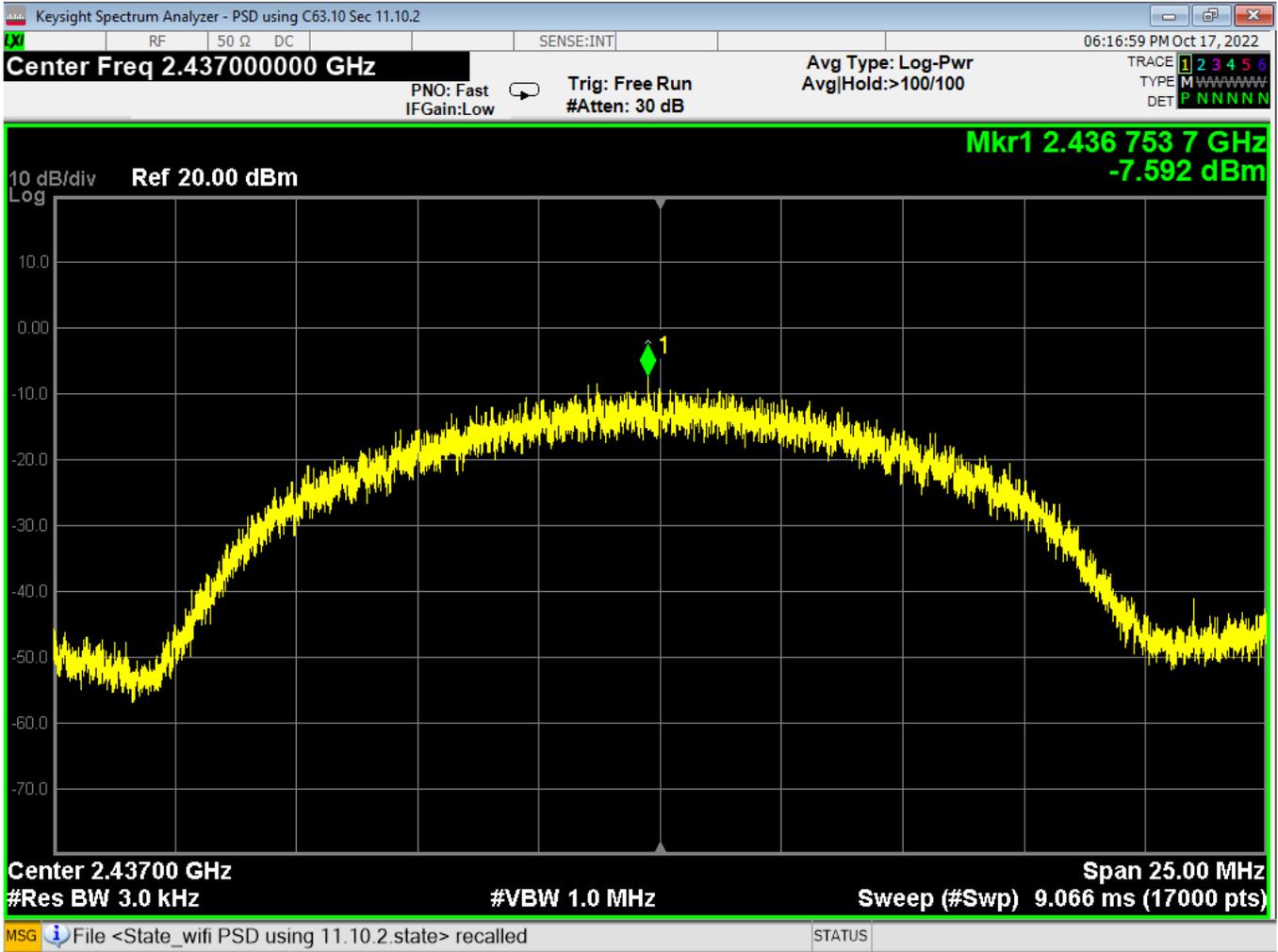
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



46 PSD, Low, Wifi B, High Data Rate



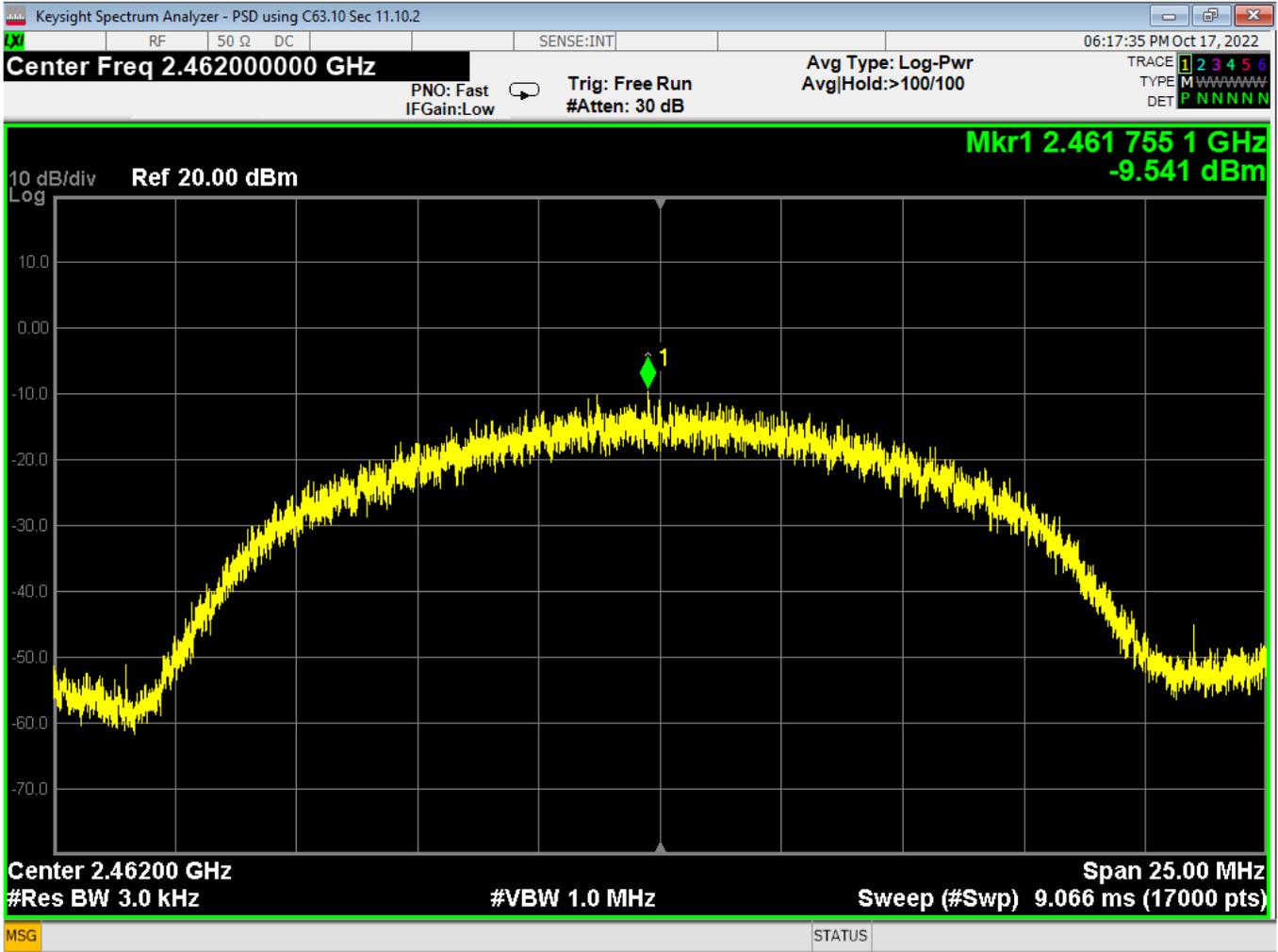
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



47 PSD, Mid, Wifi B, High Data Rate



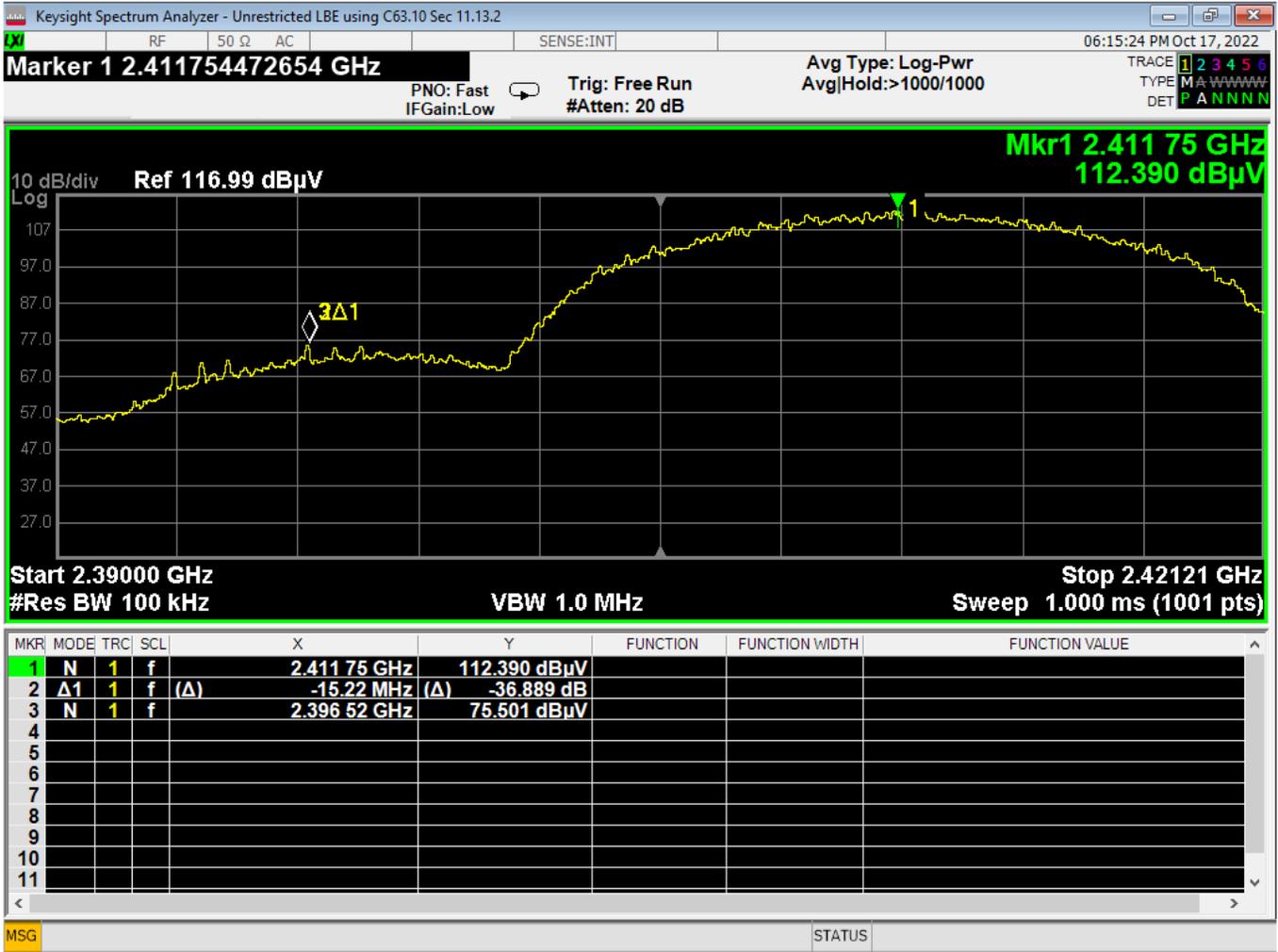
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



48 PSD, High, Wifi B, High Data Rate



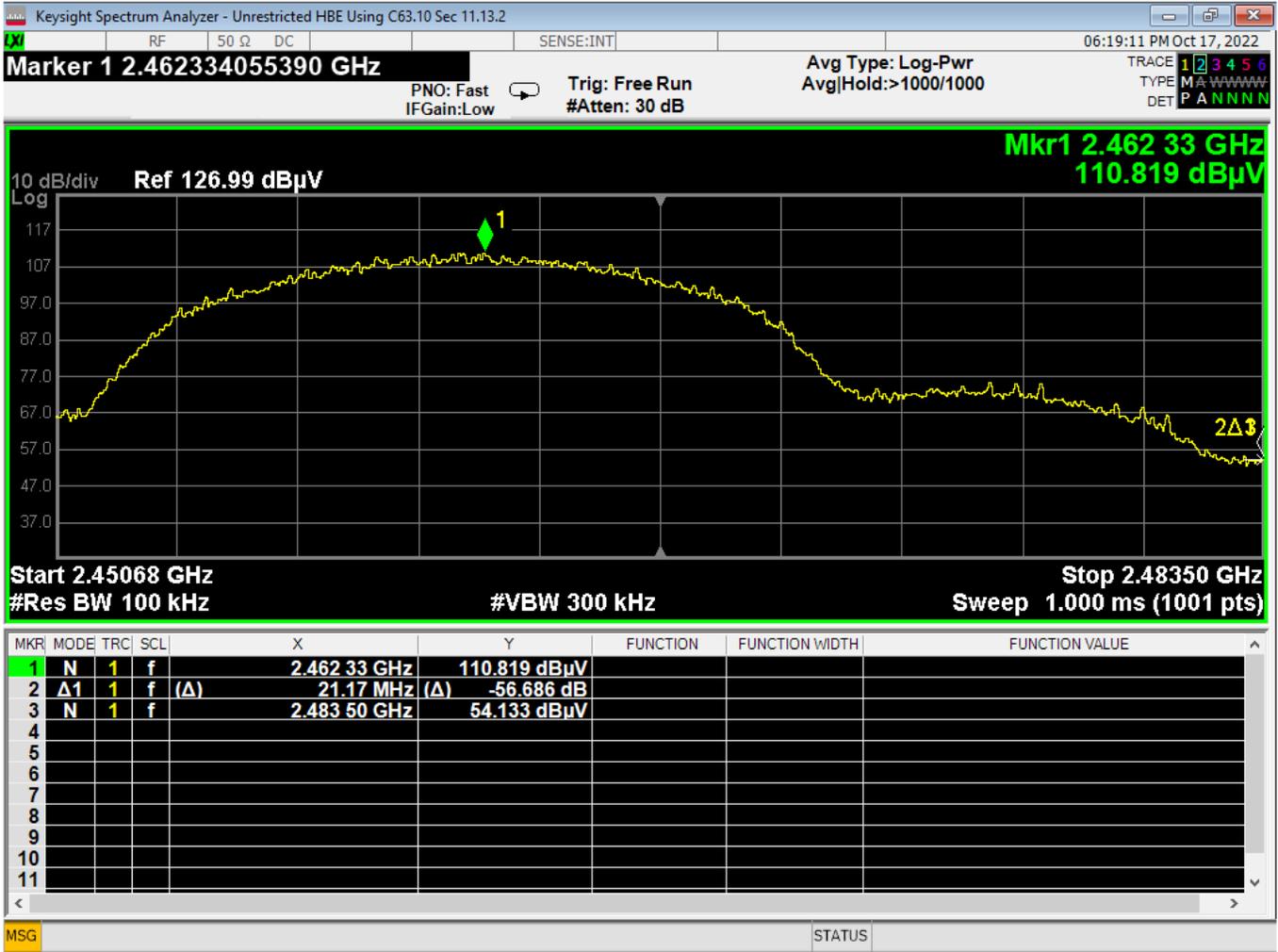
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



49 Lower Bandedge, Unrestricted, Wifi B, High Data Rate



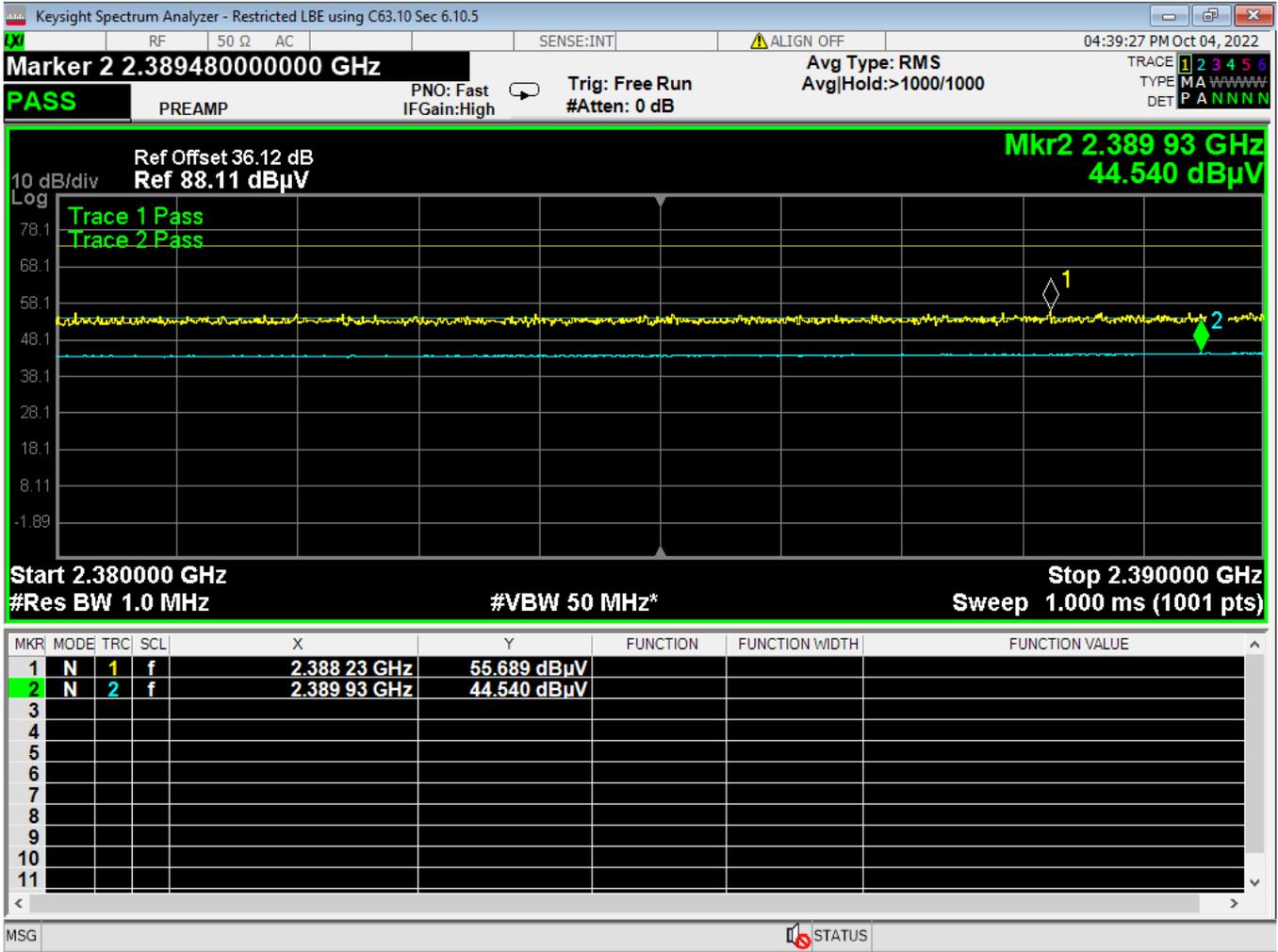
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



50 Higher Bandedge, Unrestricted, Wifi B, High Data Rate



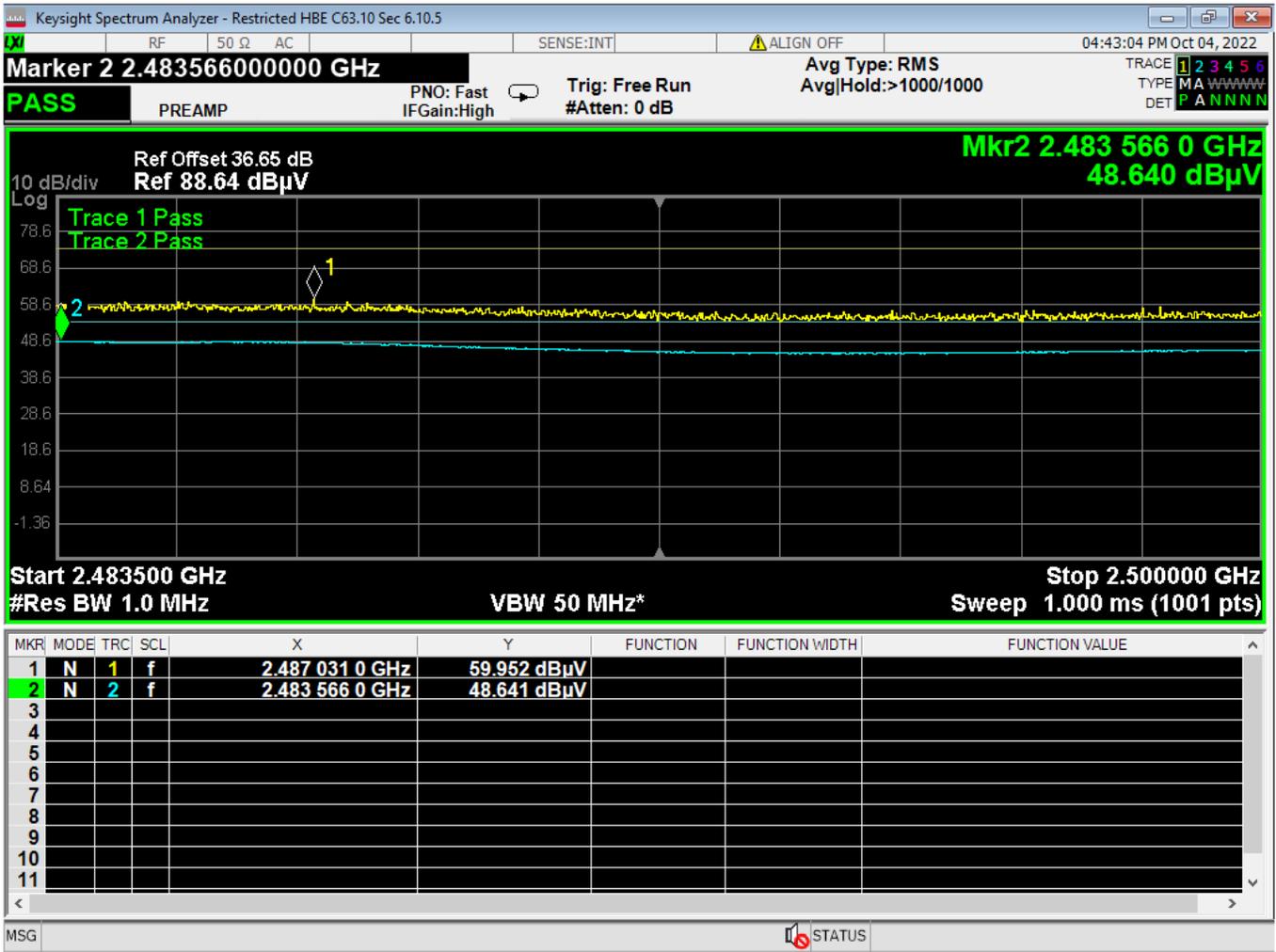
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



51 Lower Bandedge, Restricted, Wifi B, High Data Rate



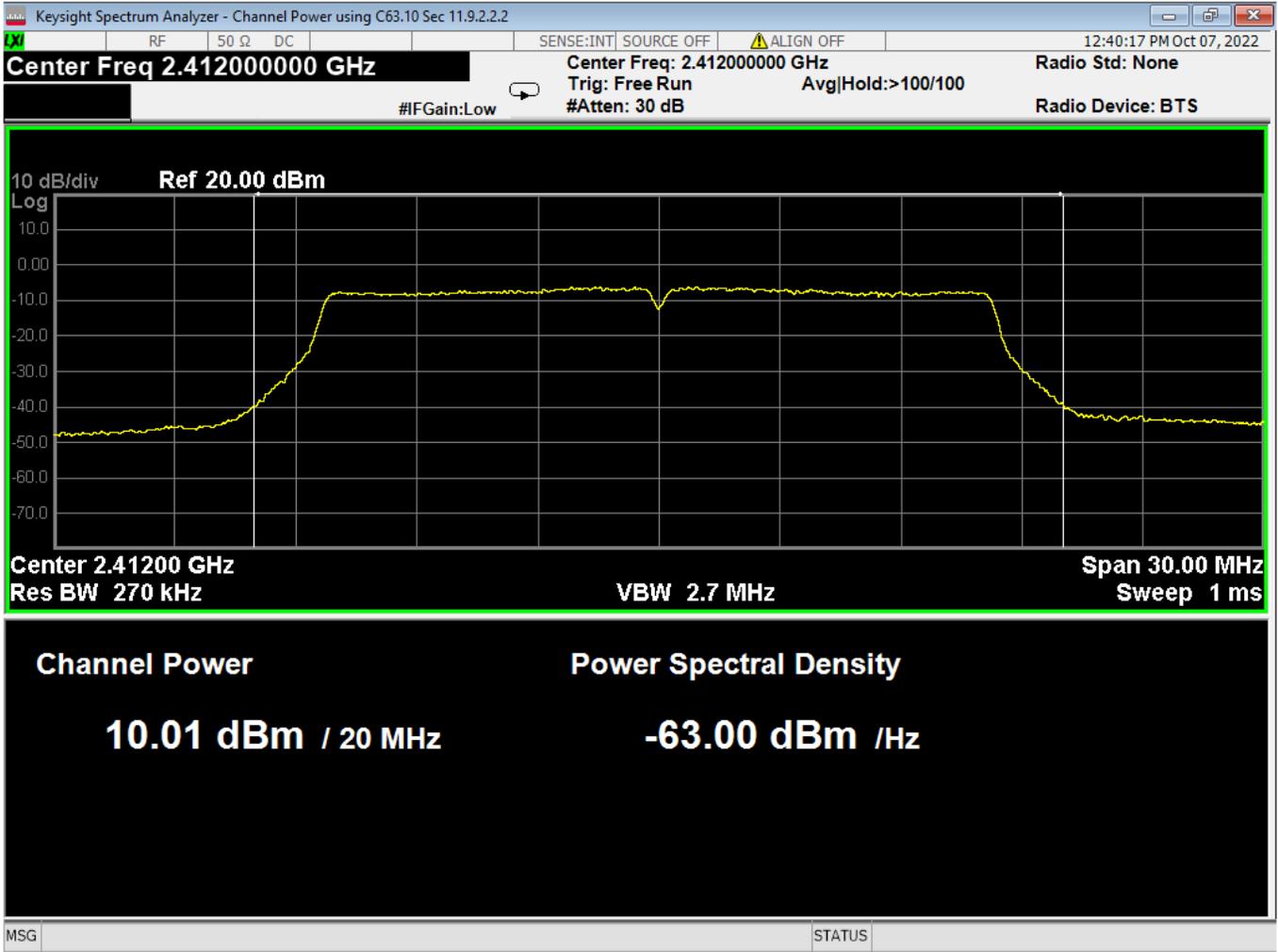
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



52 Higher Bandedge, Restricted, Wifi B, High Data Rate



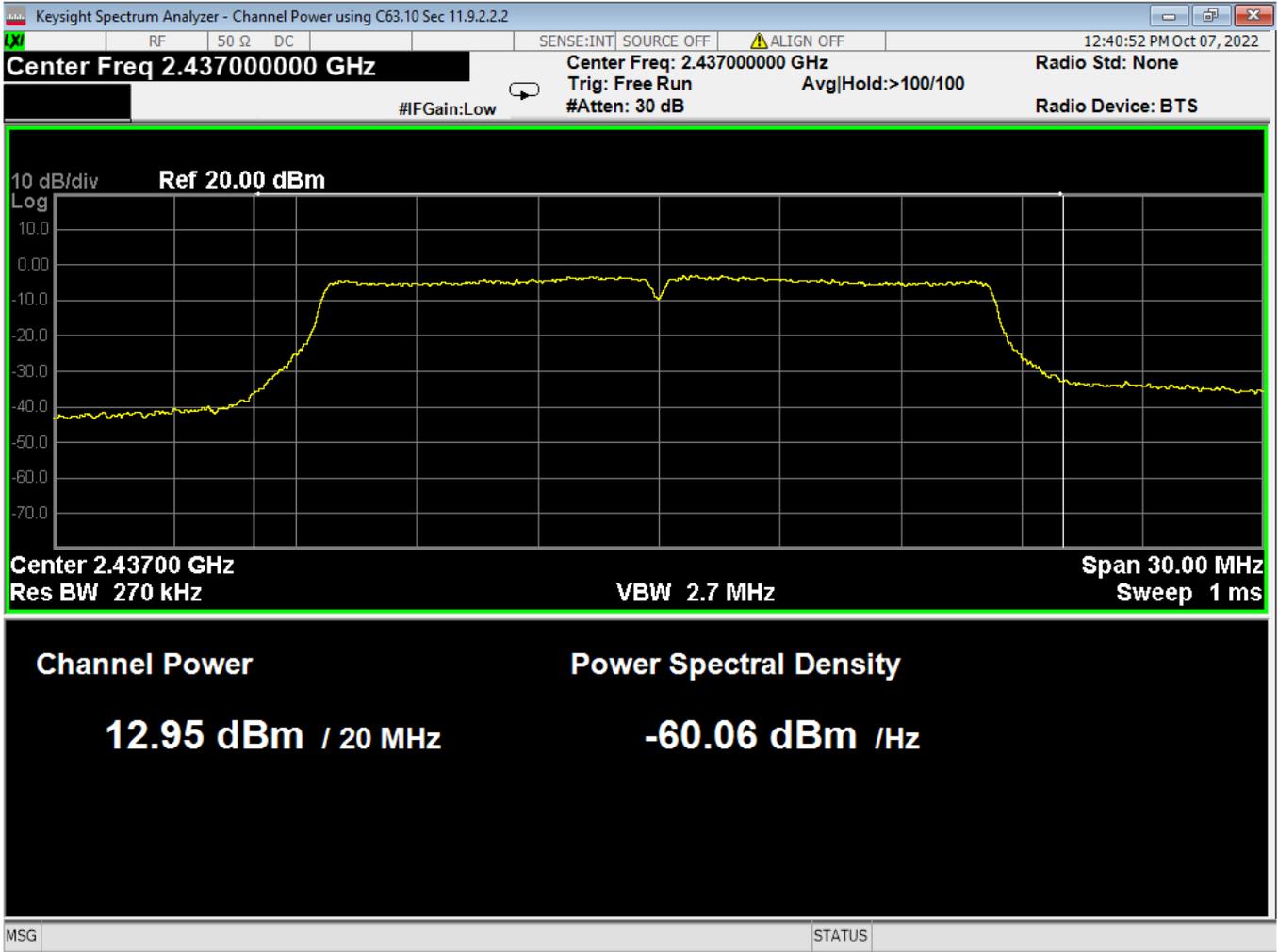
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



53 Average Power, Low, Wifi G, High Data Rate



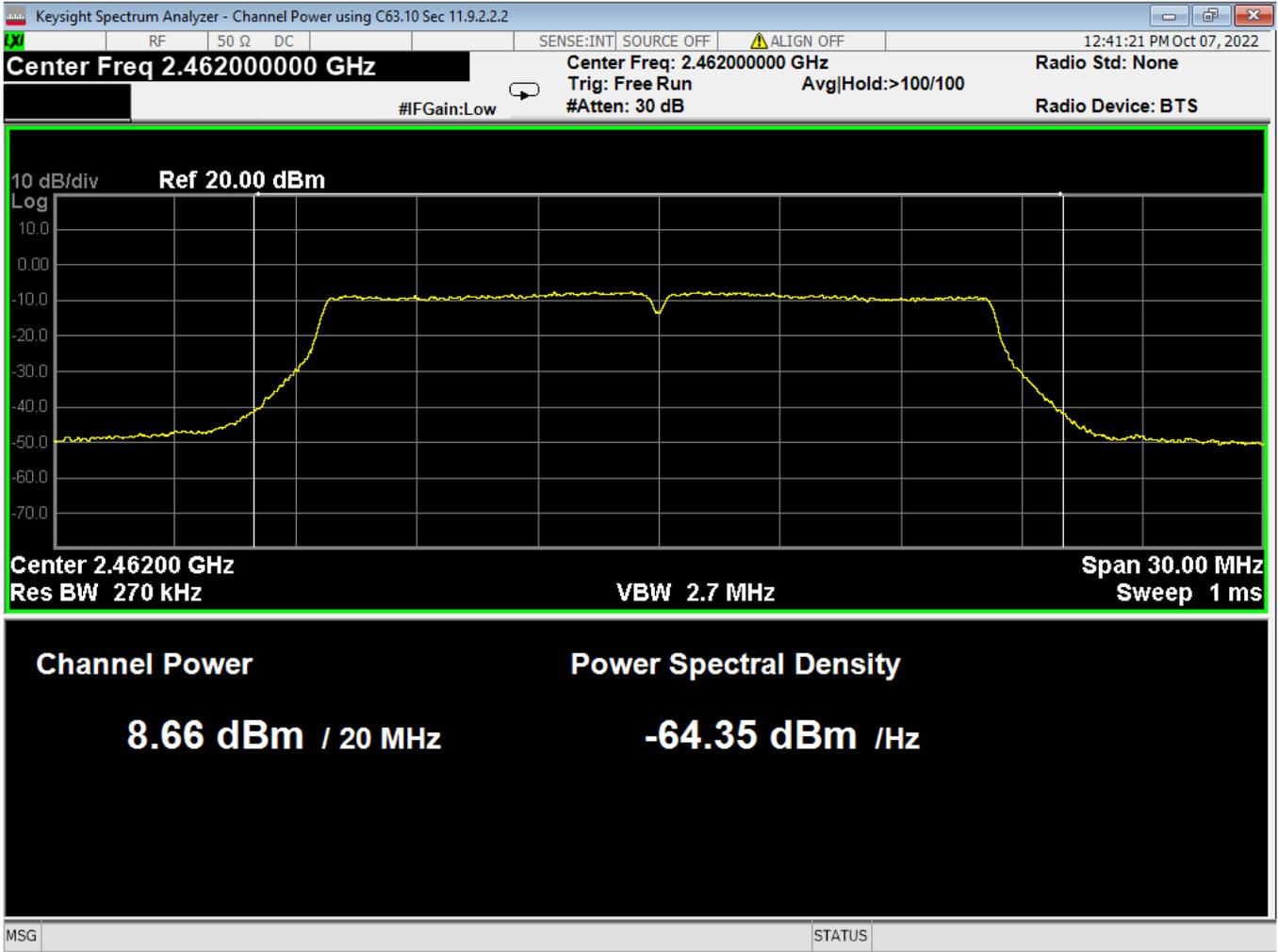
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



54 Average Power, Mid, Wifi G, High Data Rate



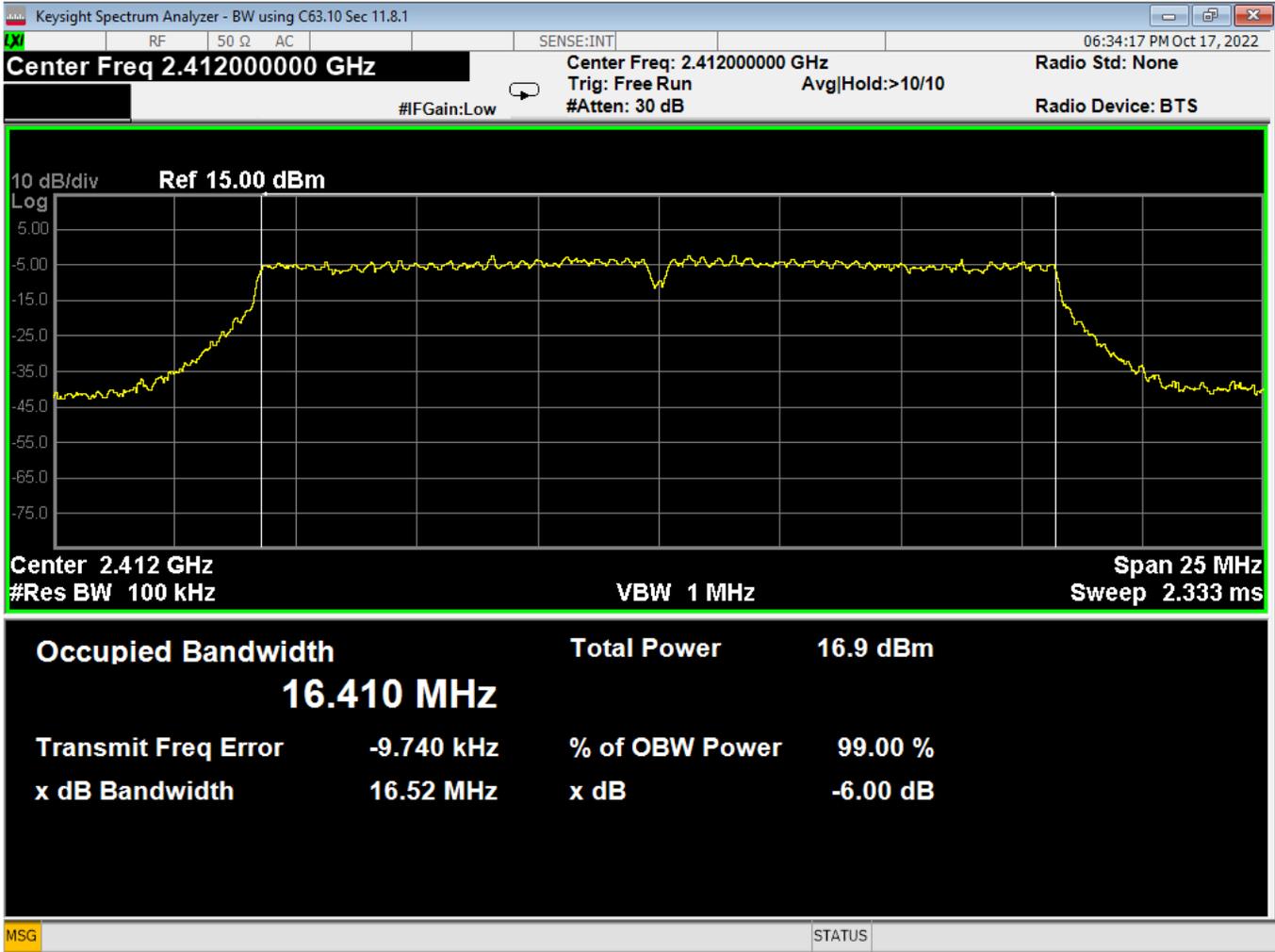
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



55 Average Power, High, Wifi G, High Data Rate



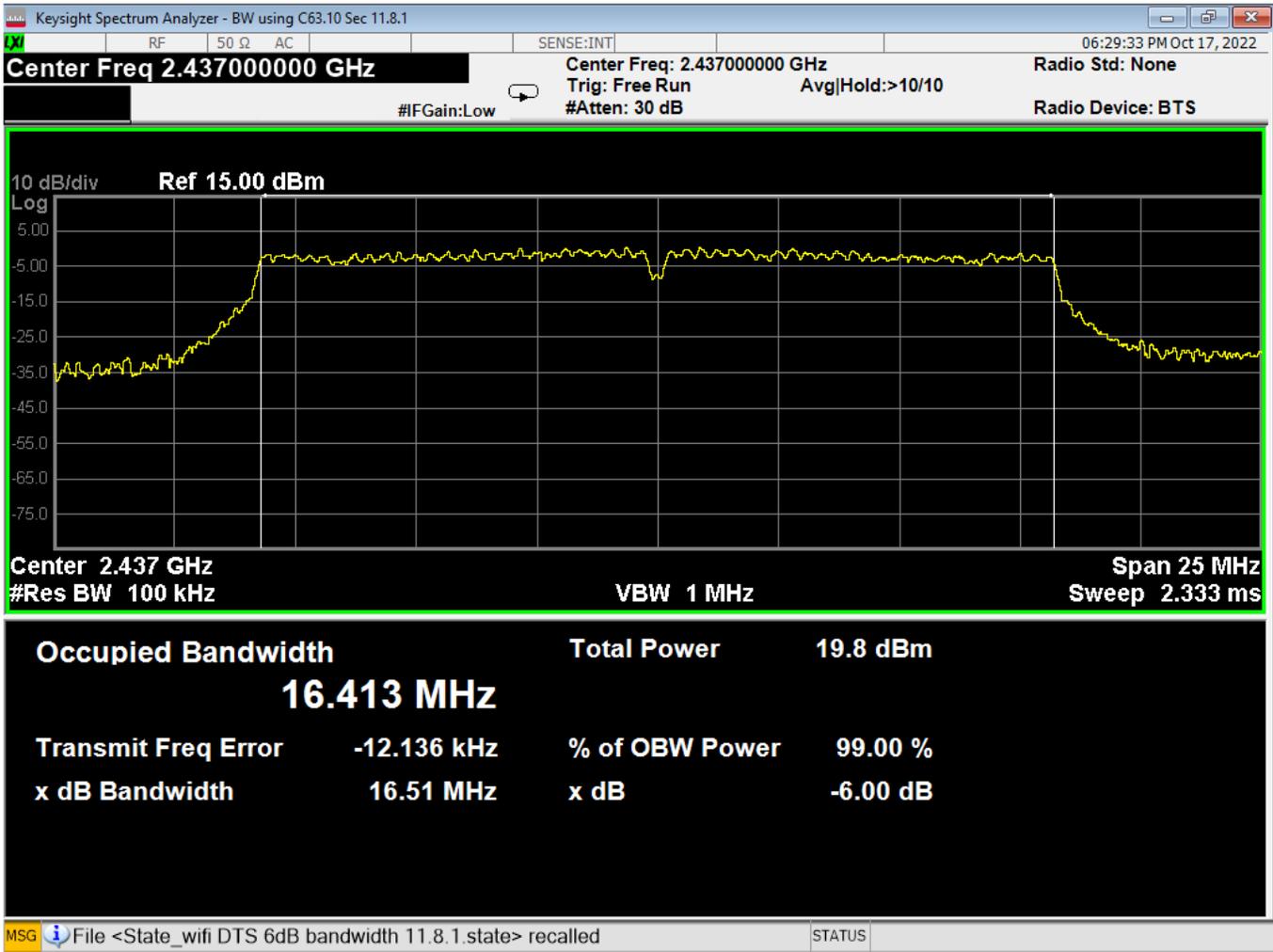
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



56 dB Bandwidth, Low, Wifi G, High Data Rate



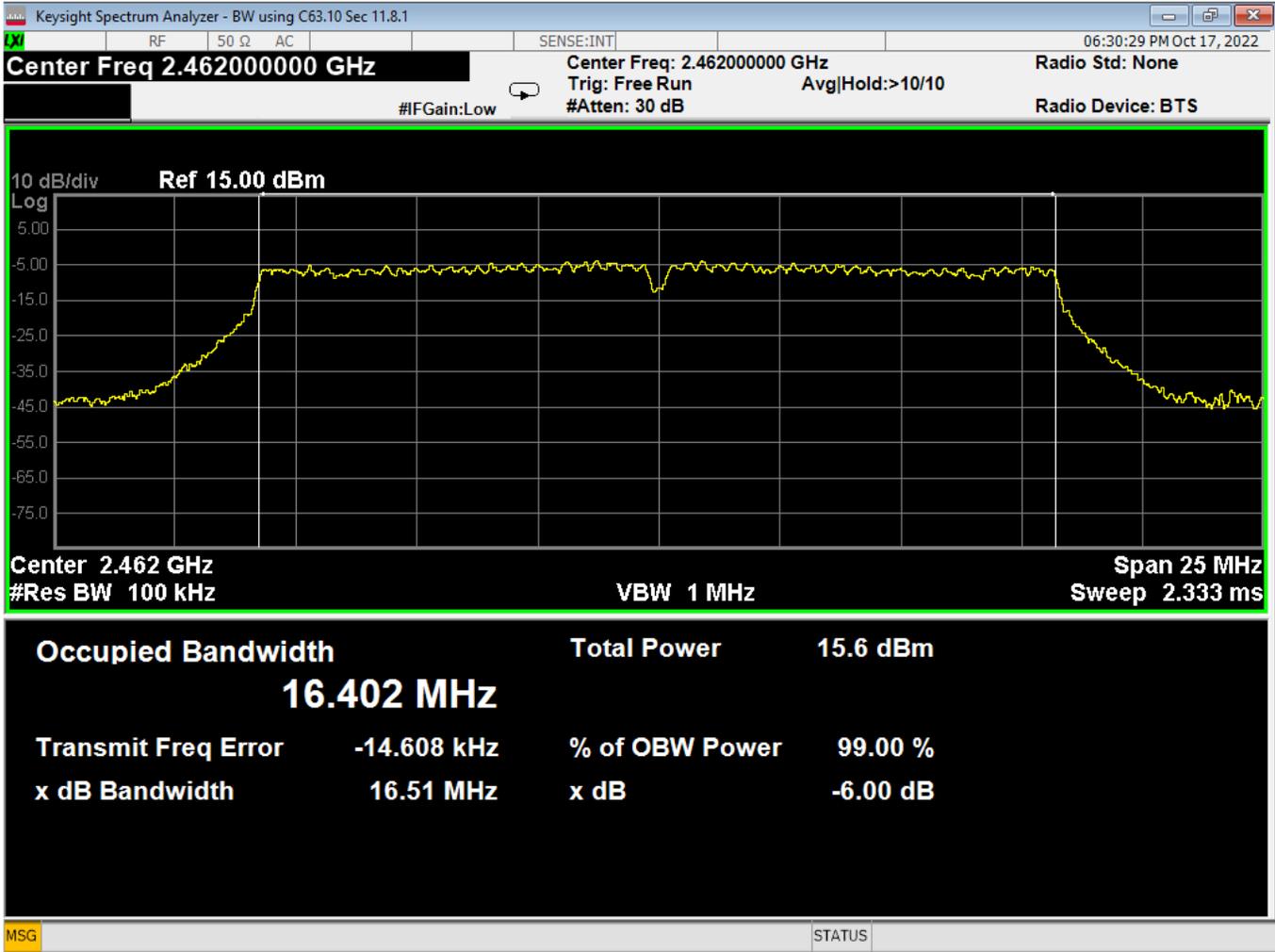
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



57 6dB Bandwidth, Mid, Wifi G, High Data Rate



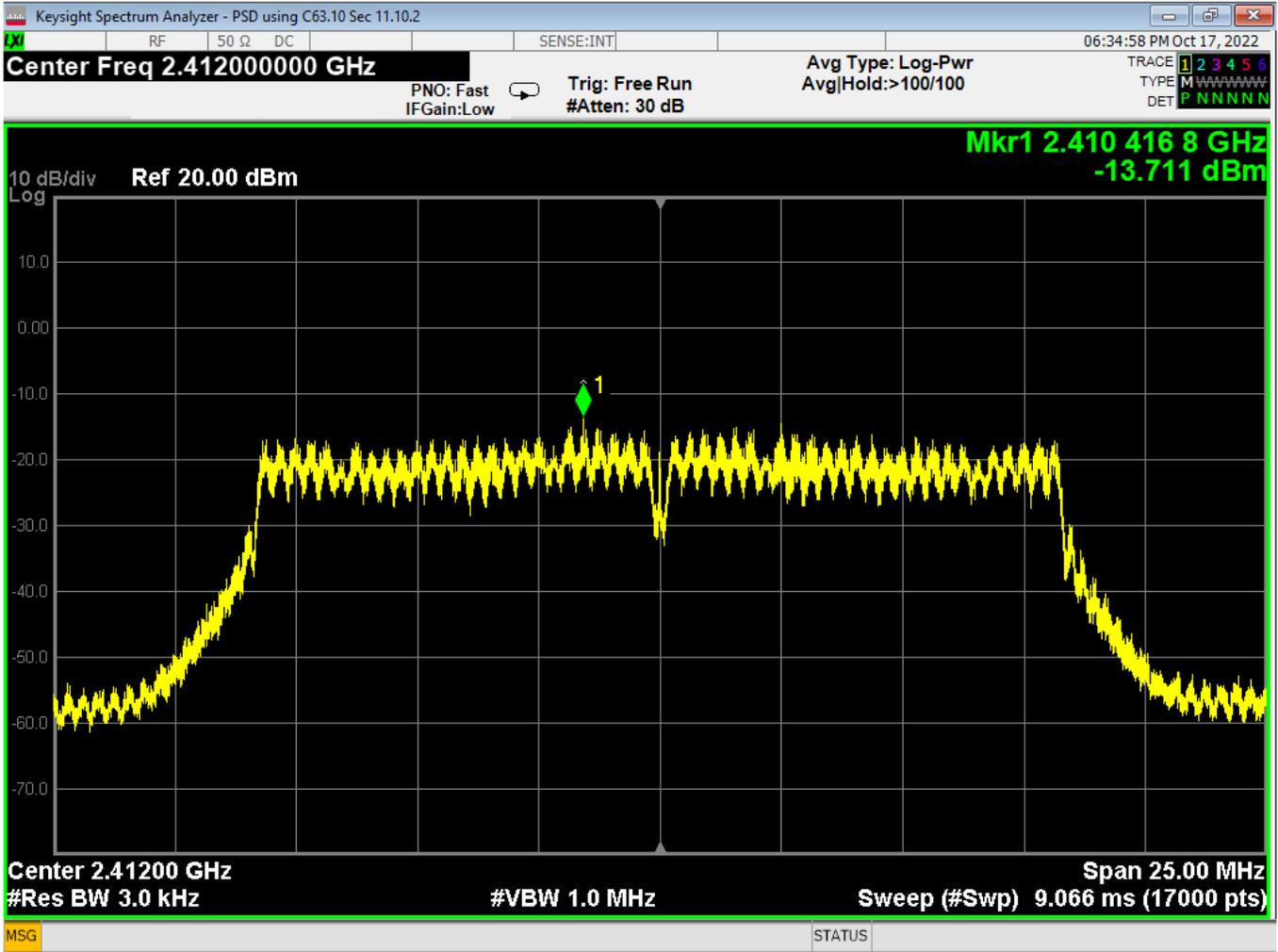
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



58 6dB Bandwidth, High, Wifi G, High Data Rate



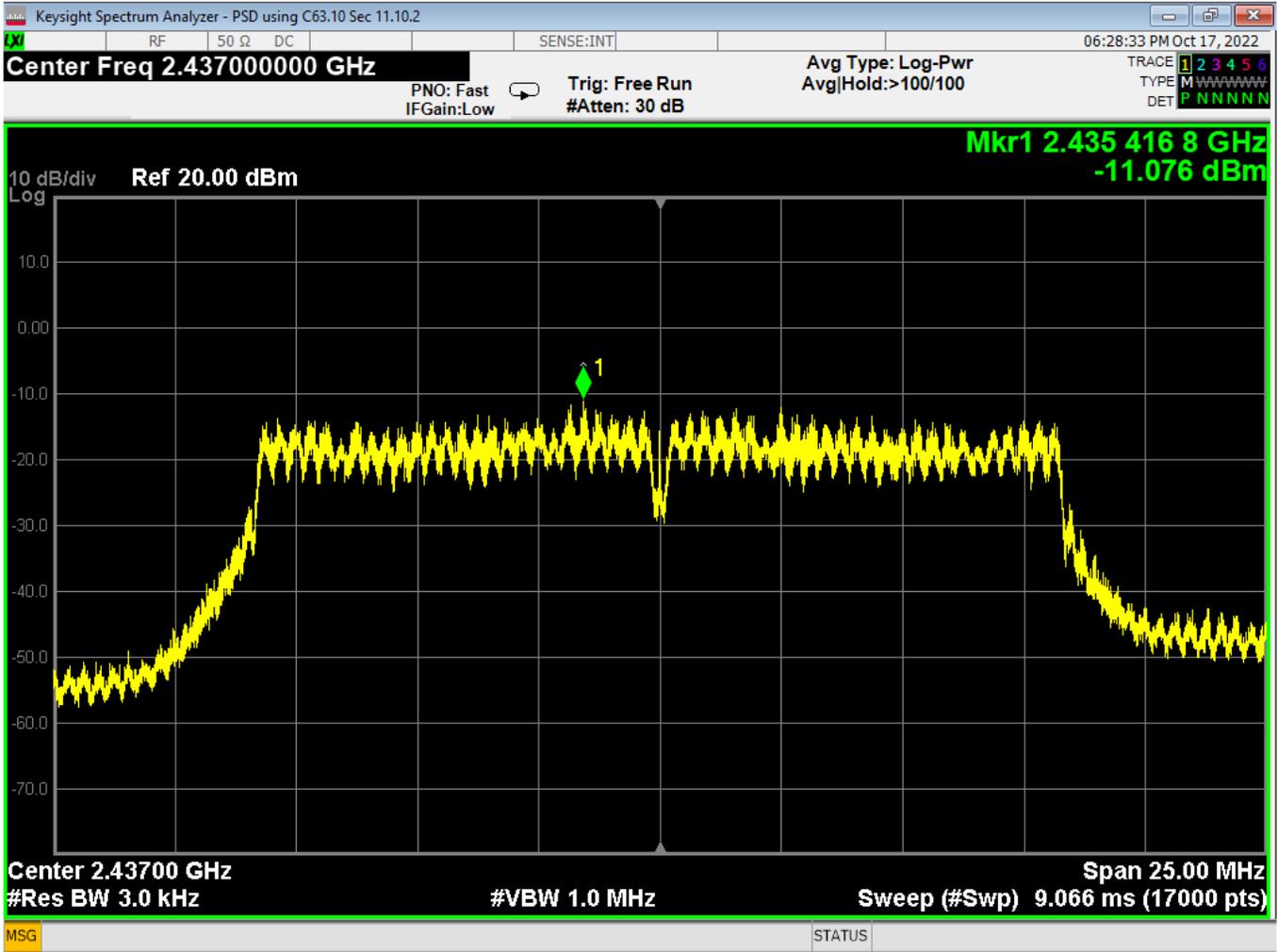
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



59 PSD, Low, Wifi G, High Data Rate



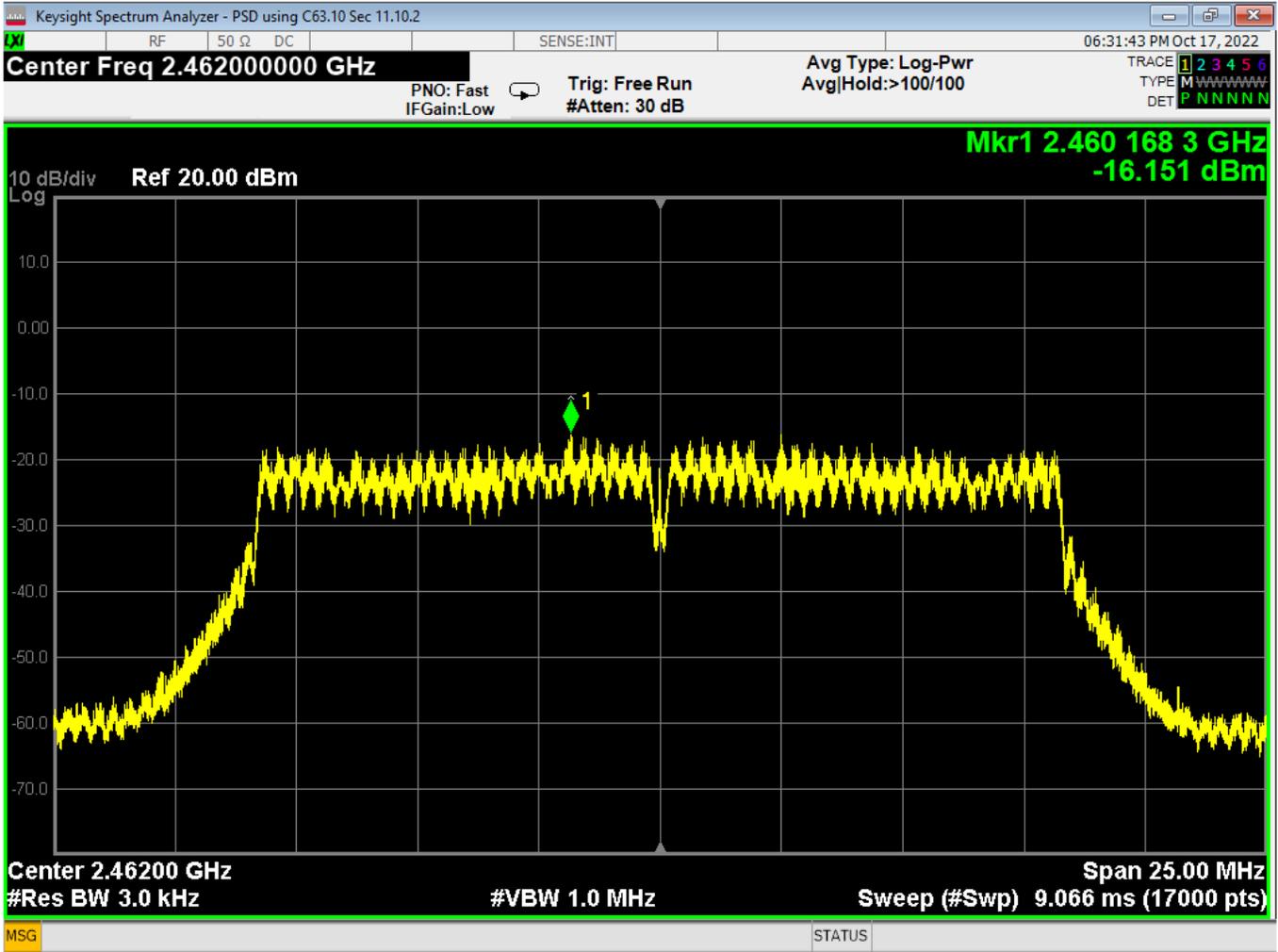
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



60 PSD, Mid, Wifi G, High Data Rate



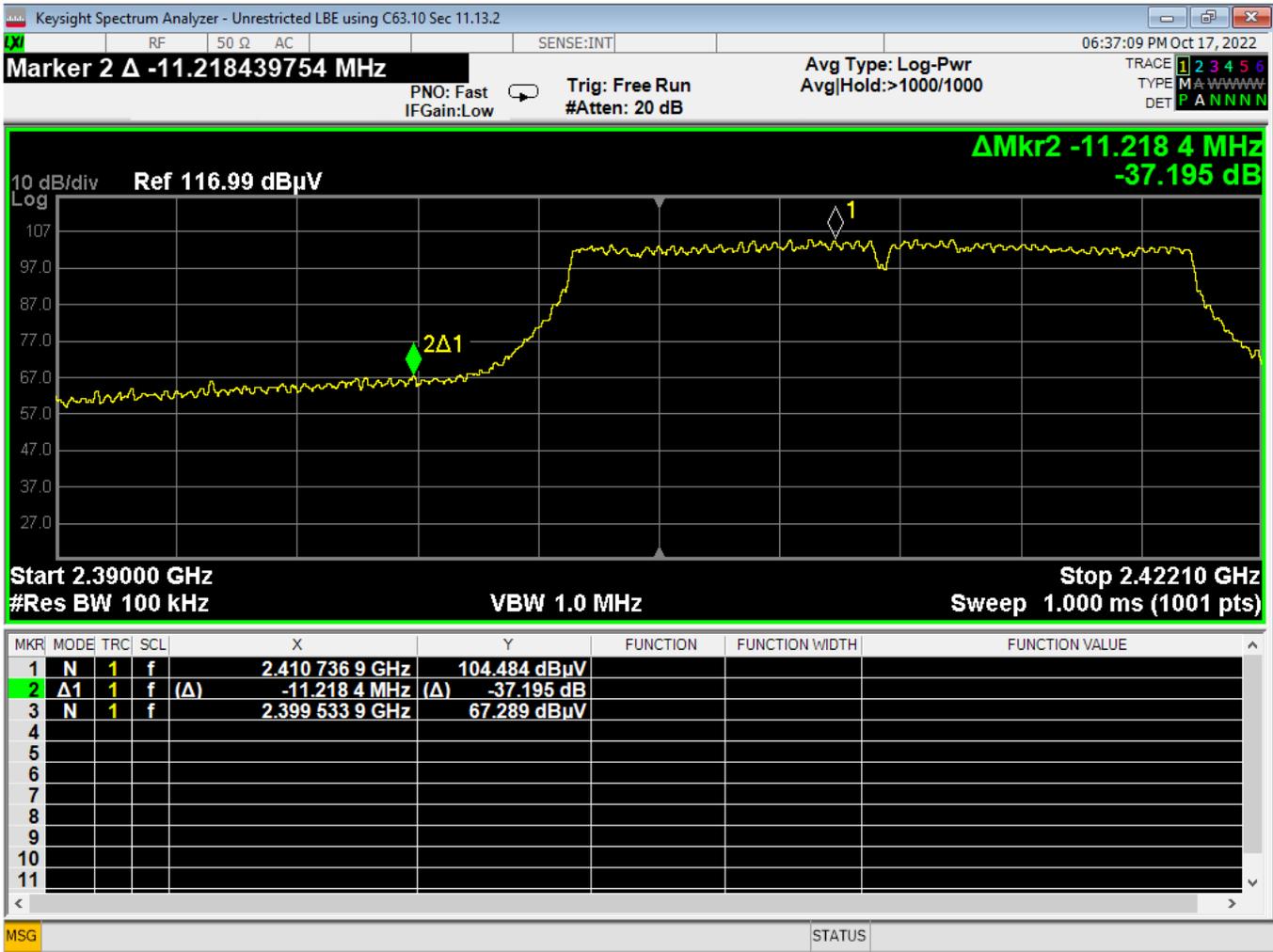
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



61 PSD, High, Wifi G, High Data Rate



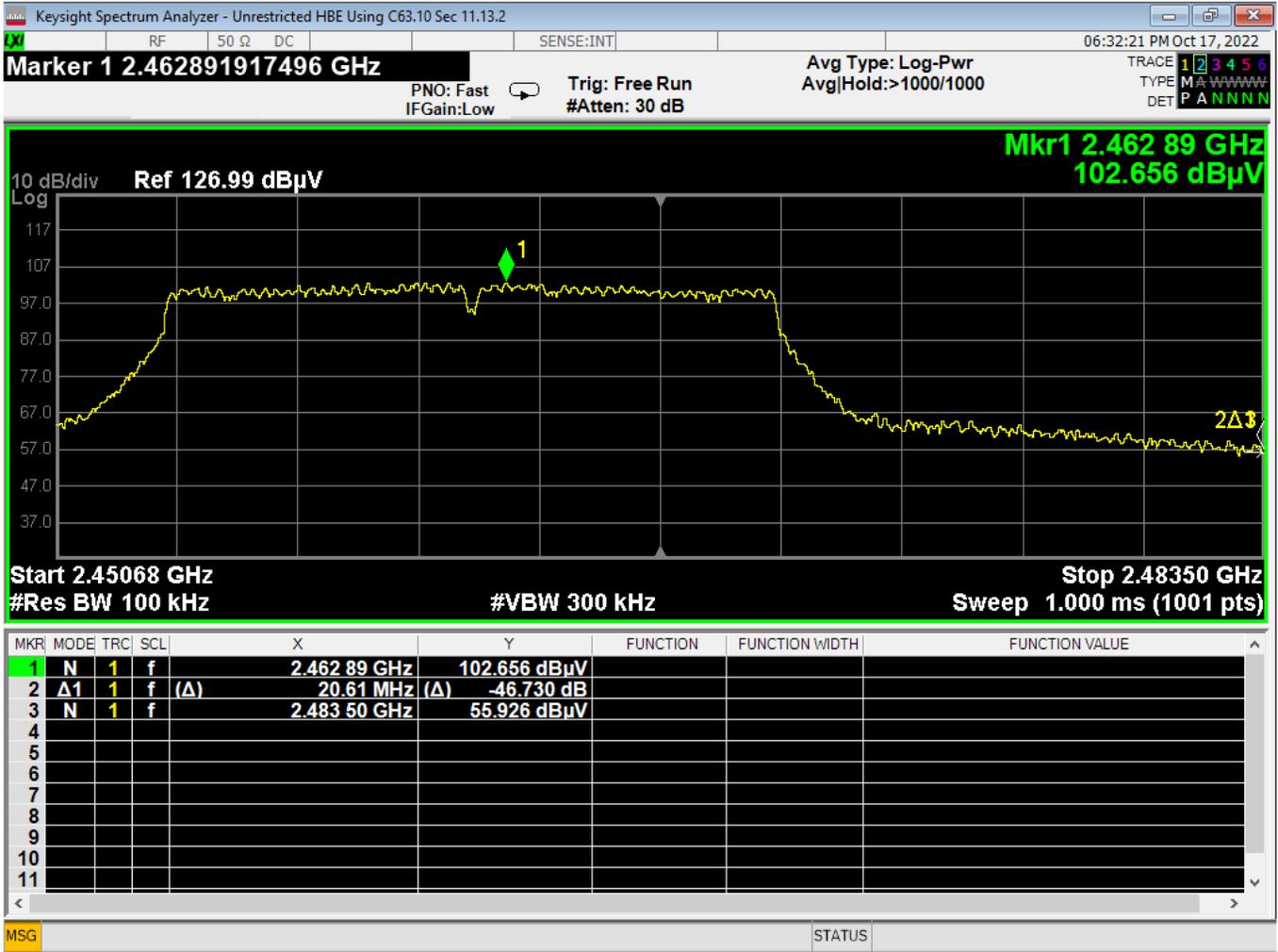
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



62 Lower Bandedge, Unrestricted, Wifi G, High Data Rate



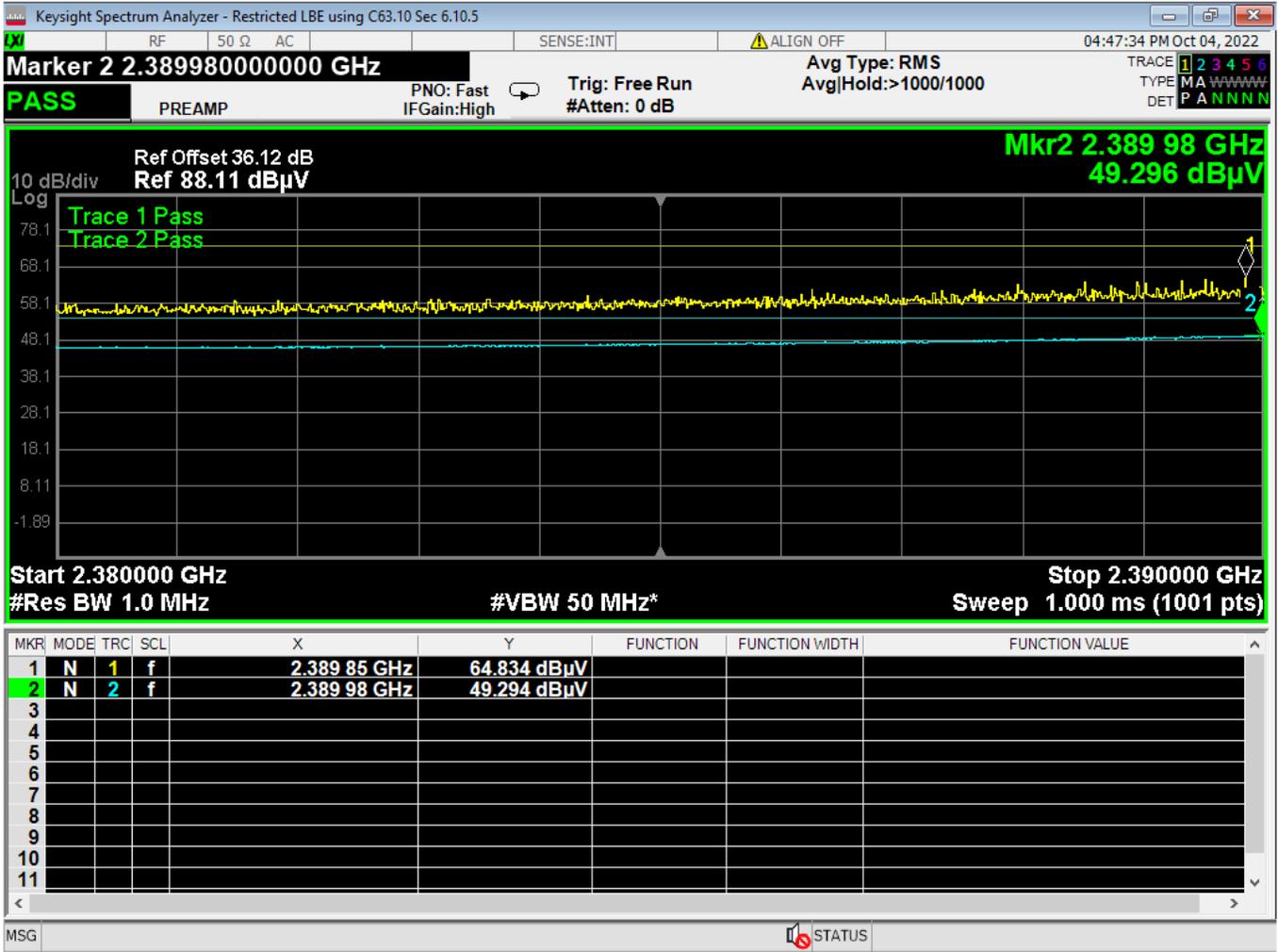
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



63 Higher Bandedge, Unrestricted, Wifi G, High Data Rate



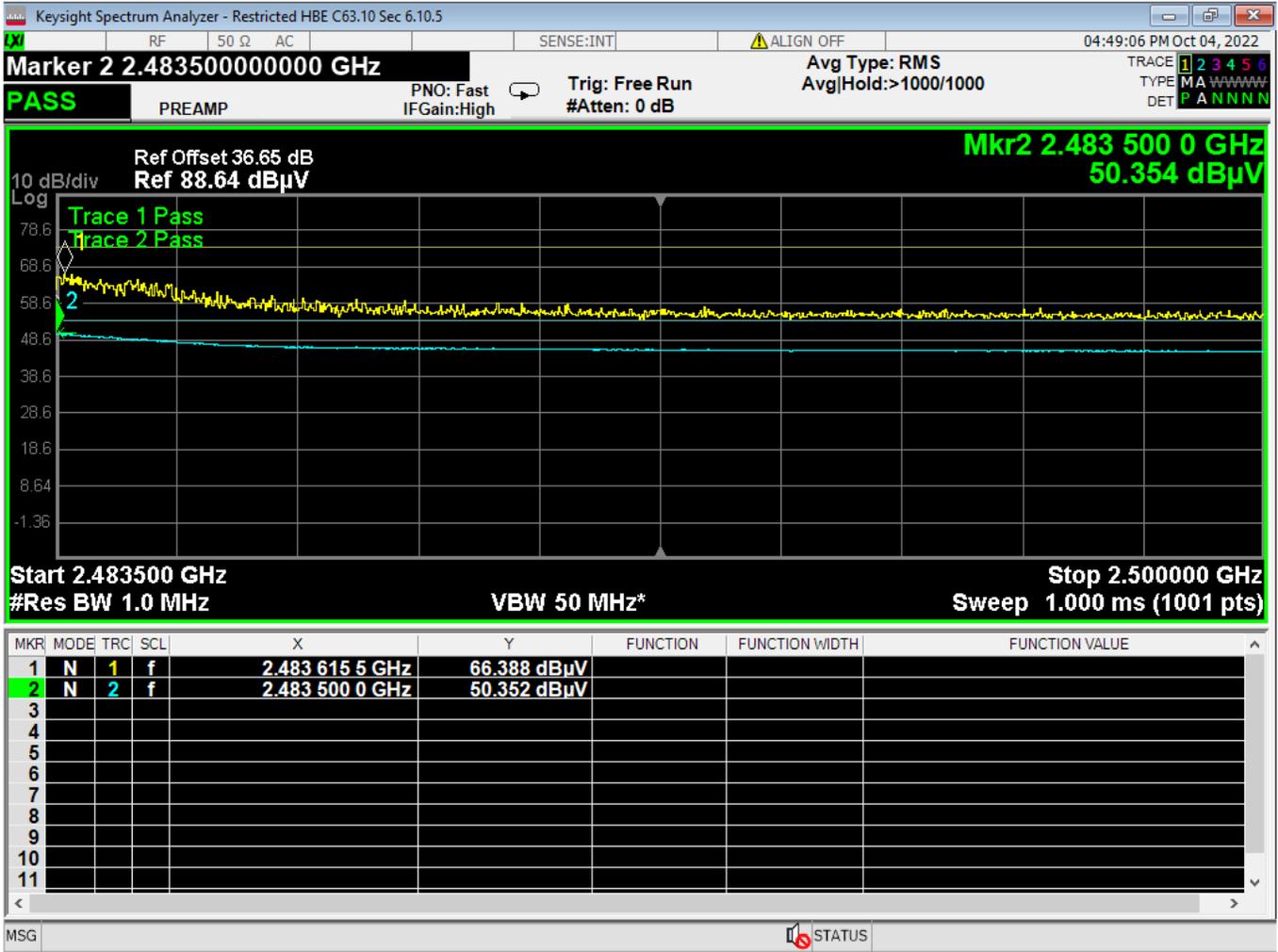
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



64 Lower Bandedge, Restricted, Wifi G, High Data Rate



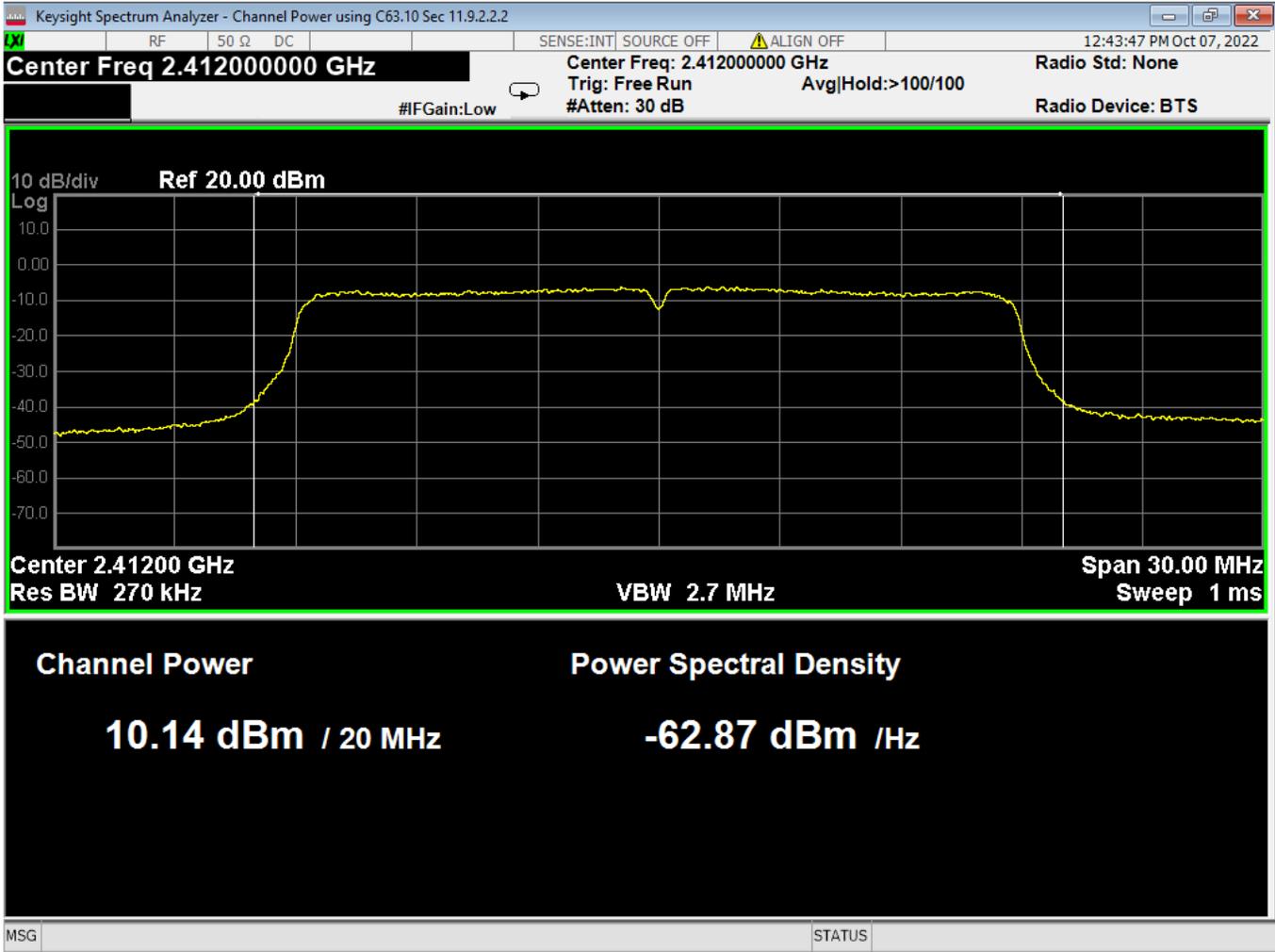
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



65 Higher Bandedge, Restricted, Wifi G, High Data Rate



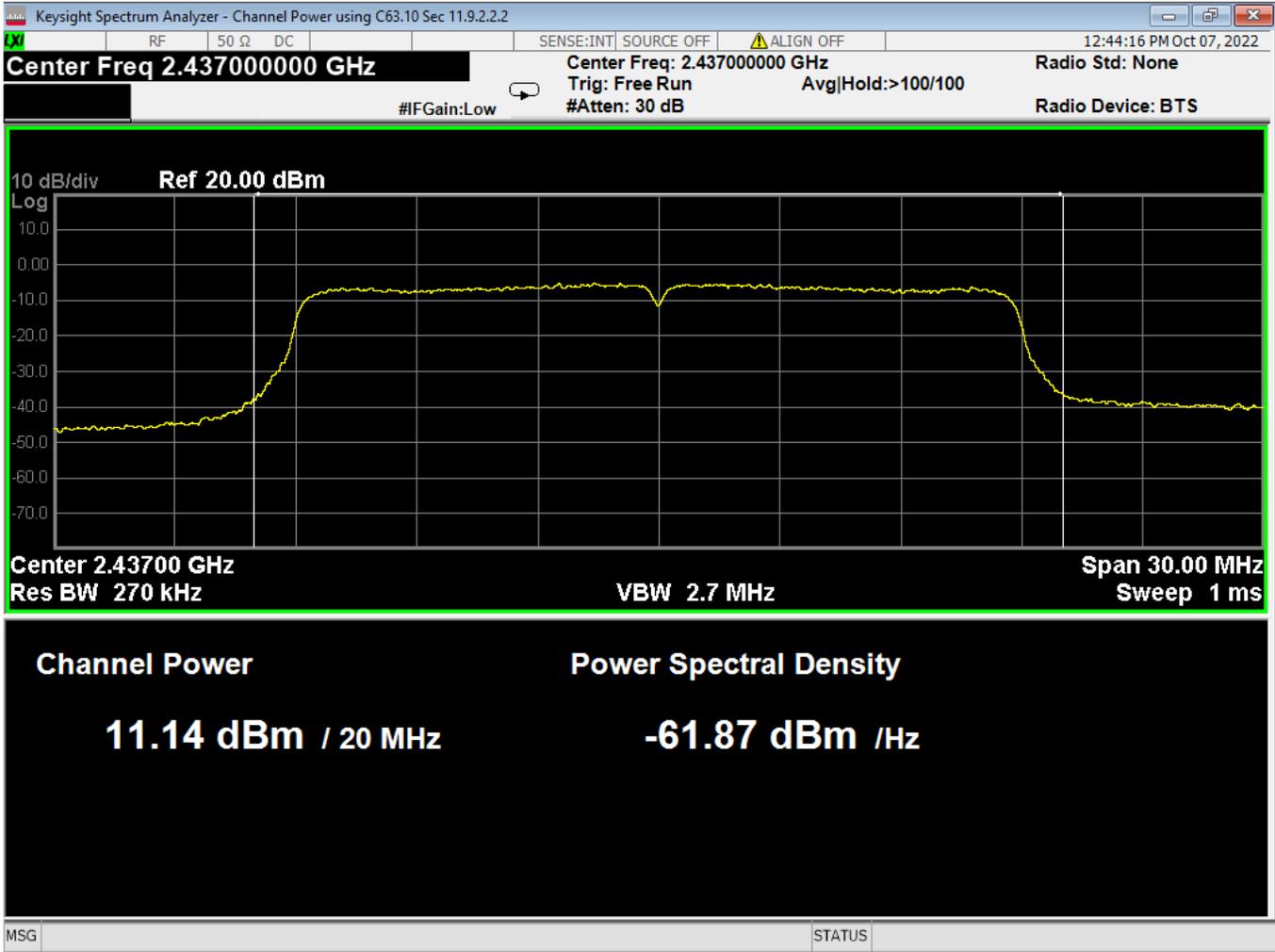
Report Number:	R20220901-21-E5A	Rev	A
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66 Average Power, Low, Wifi N, High Data Rate



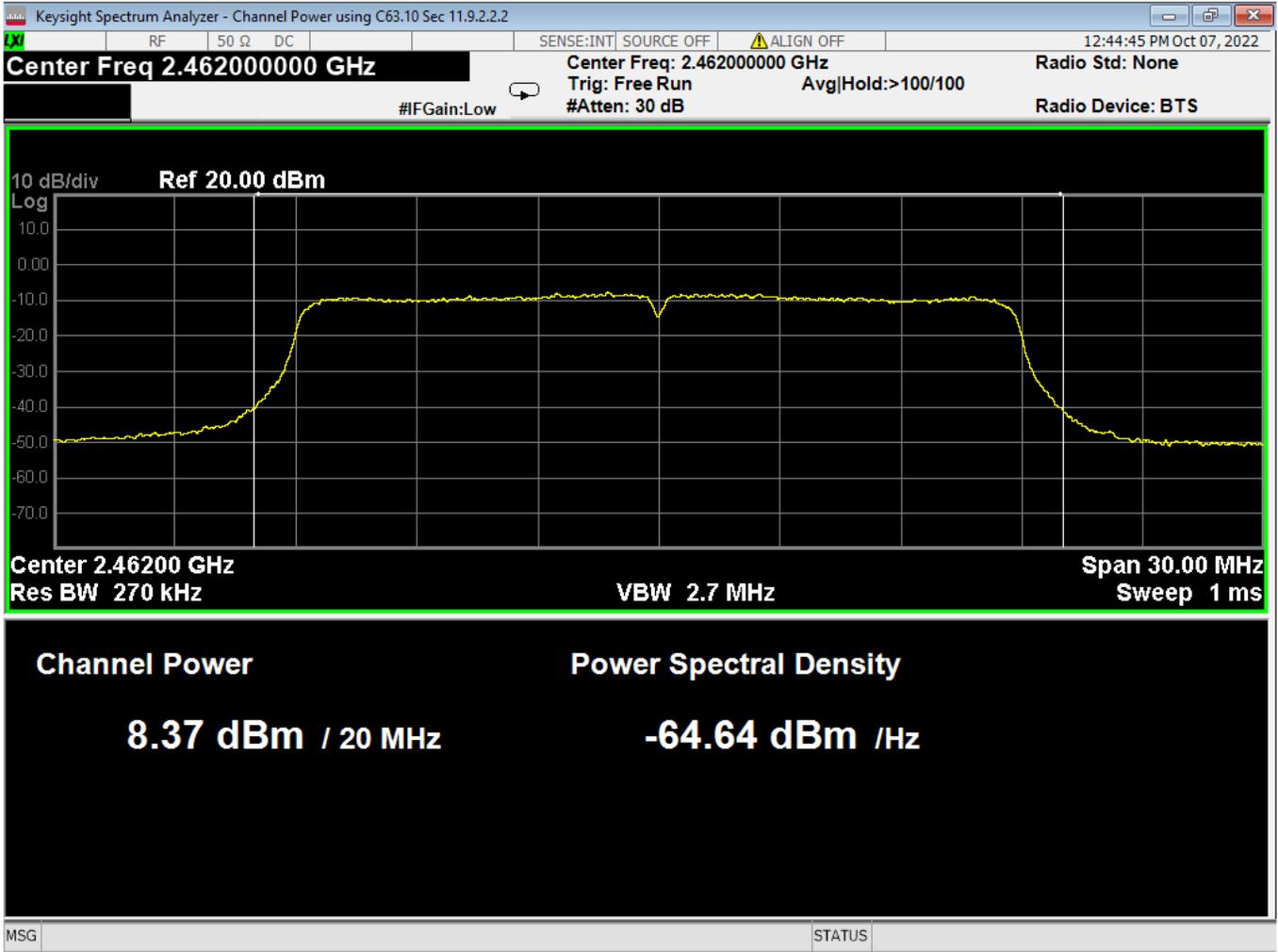
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



67 Average Power, Mid, Wifi N, High Data Rate



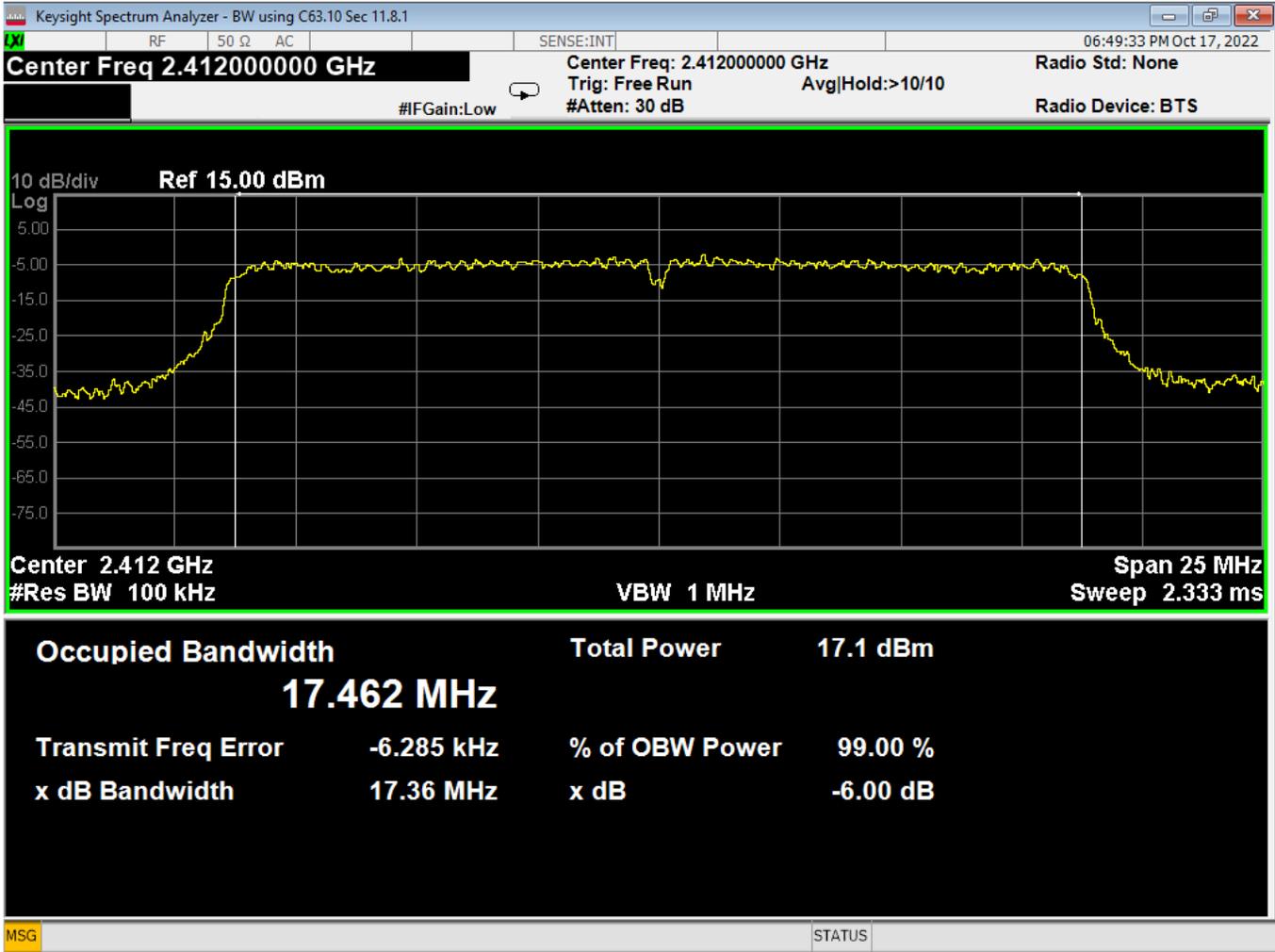
Report Number:	R20220901-21-E5A	Rev	A
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68 Average Power, High, Wifi N, High Data Rate



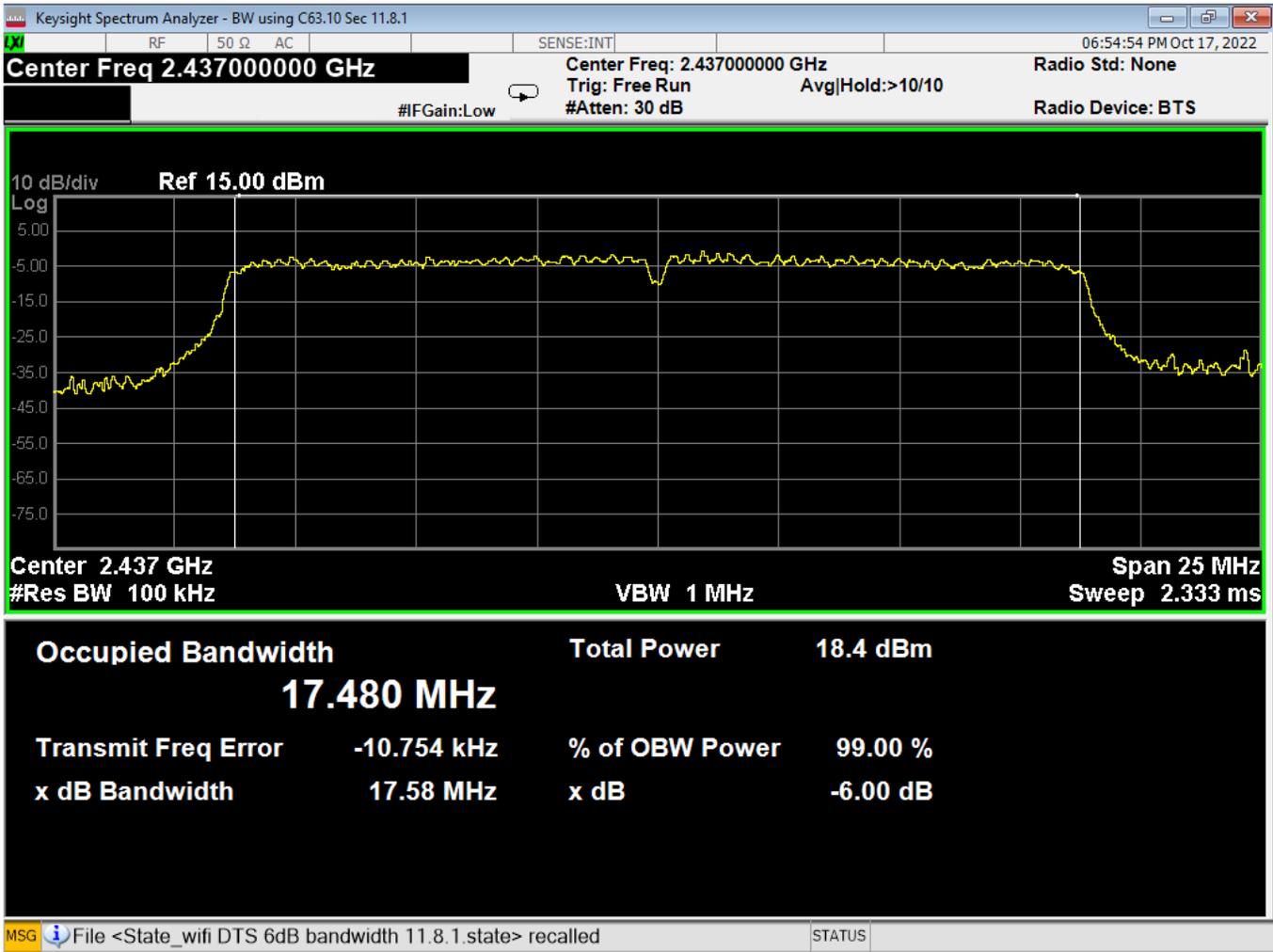
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



69 dB Bandwidth, Low, Wifi N, High Data Rate



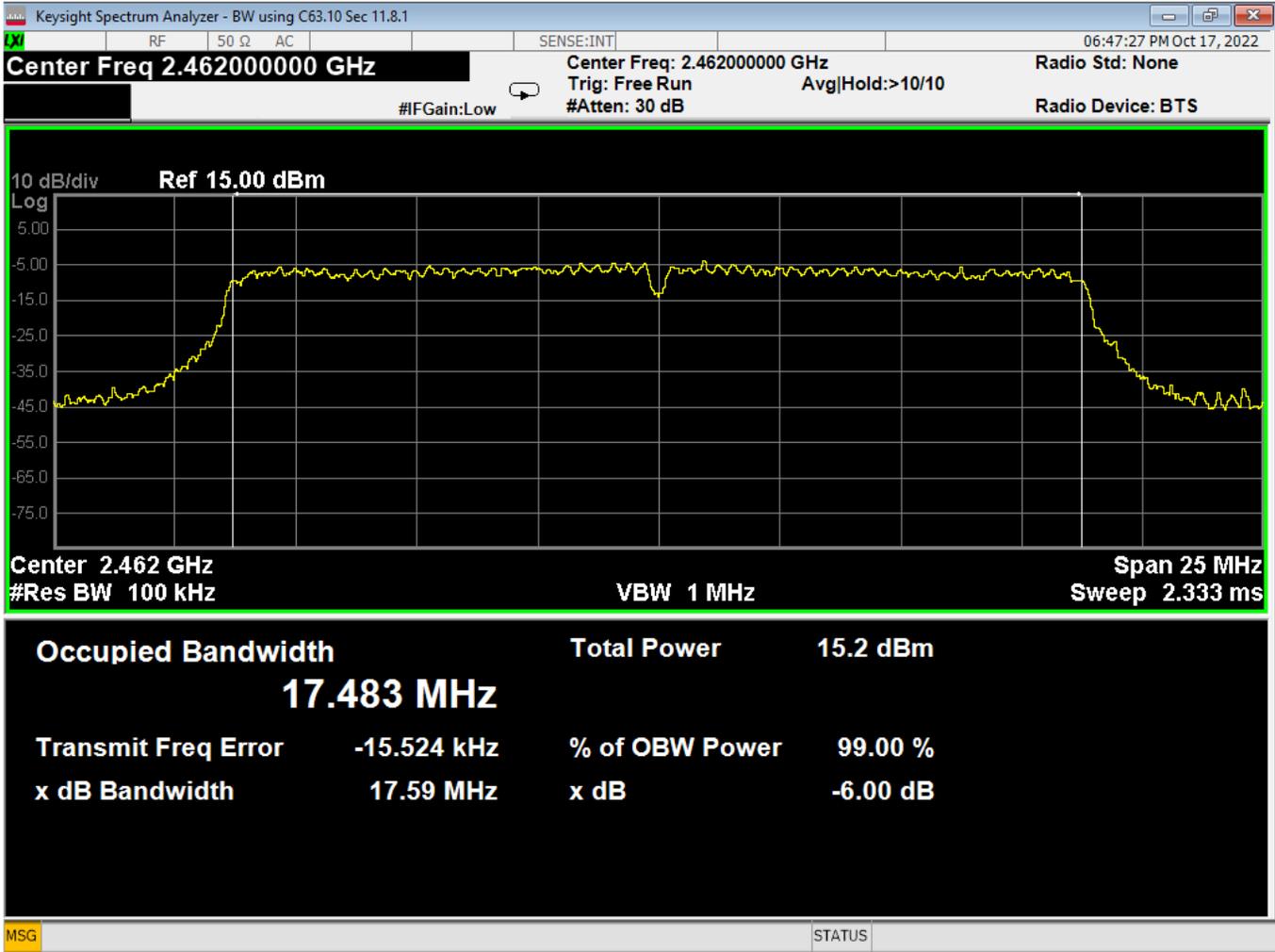
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



70 6dB Bandwidth, Mid, Wifi N, High Data Rate



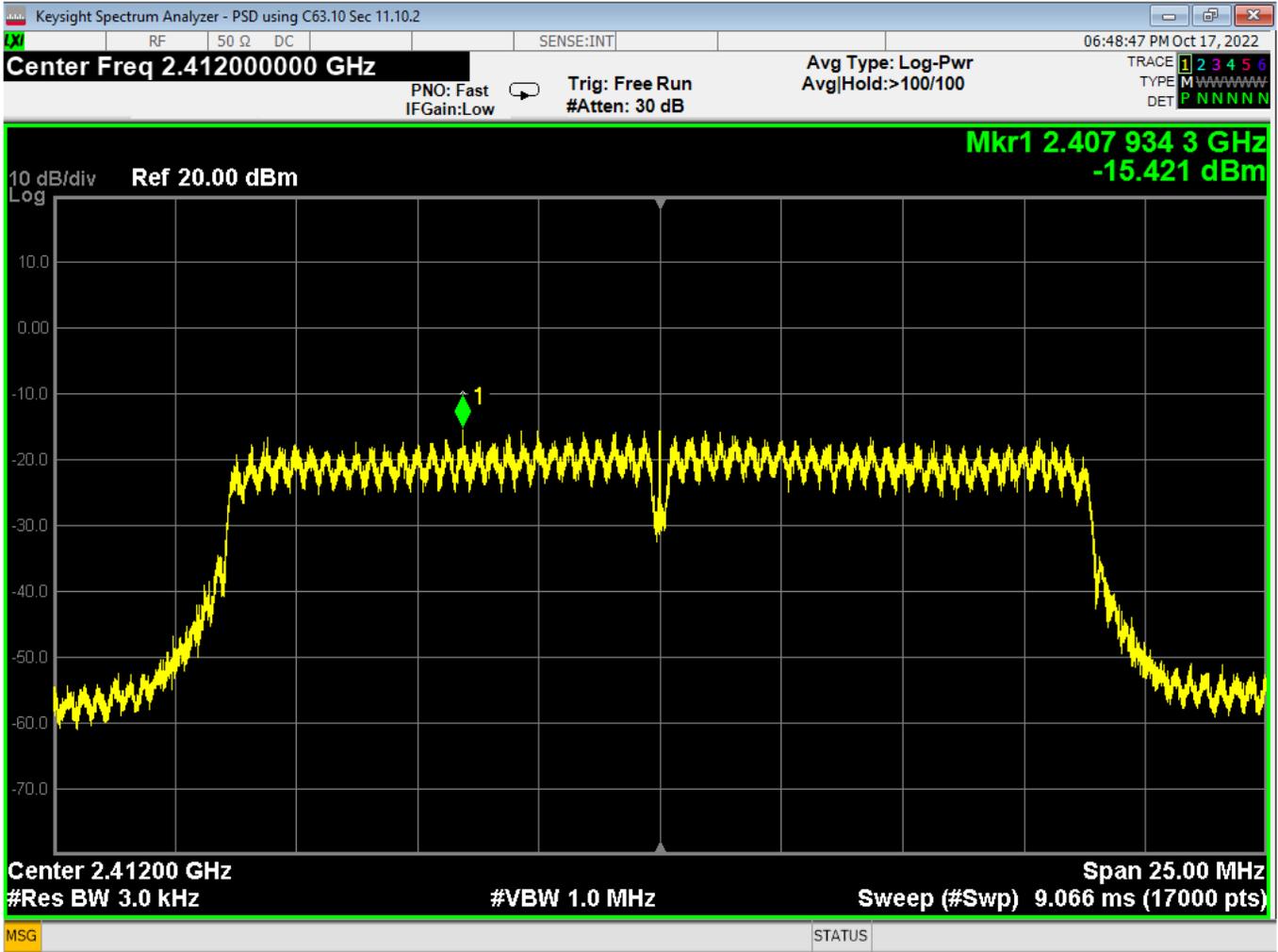
Report Number:	R20220901-21-E5A	Rev	A
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71 6dB Bandwidth, High, Wifi N, High Data Rate



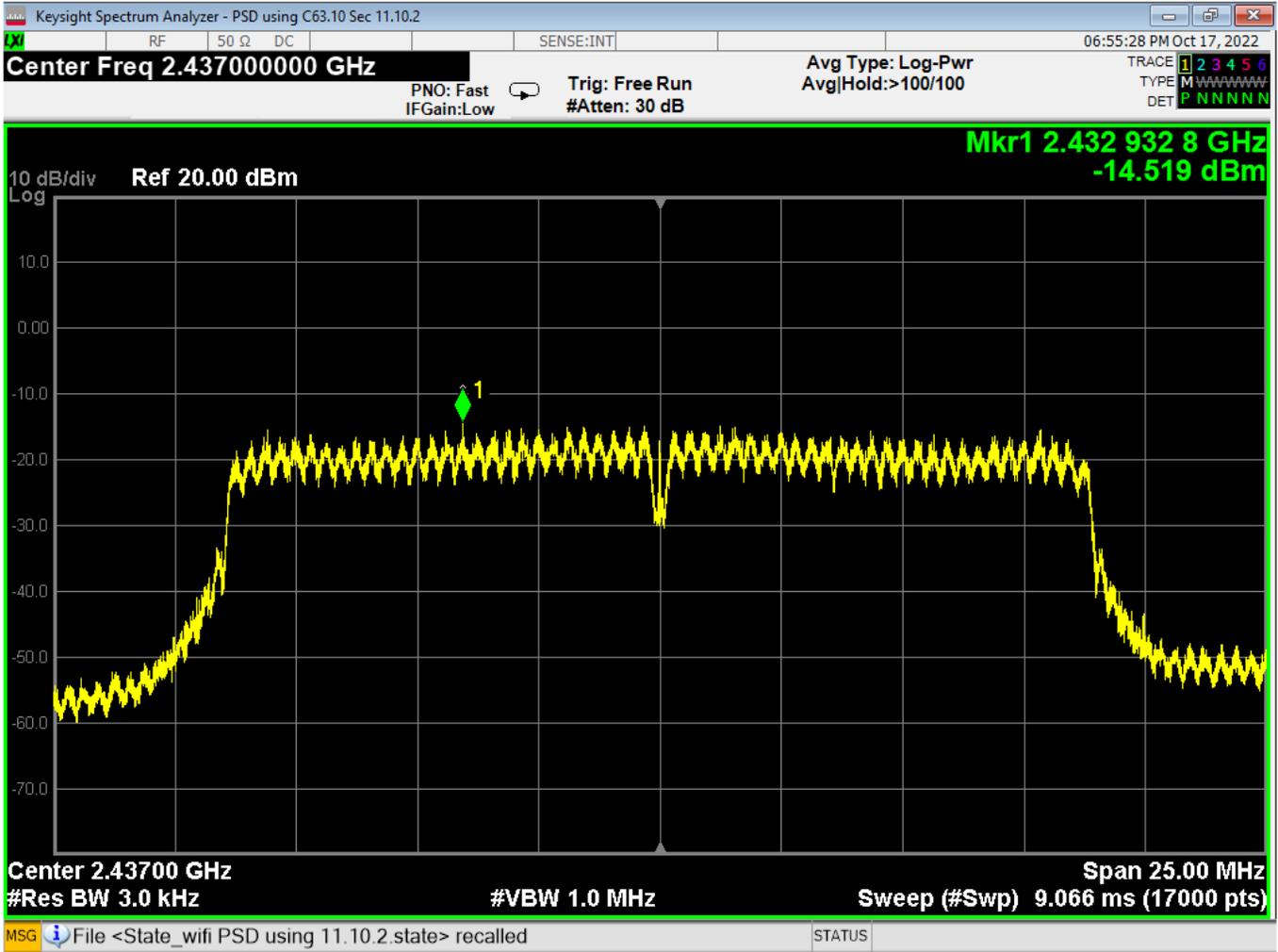
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



72 PSD, Low, Wifi N, High Data Rate



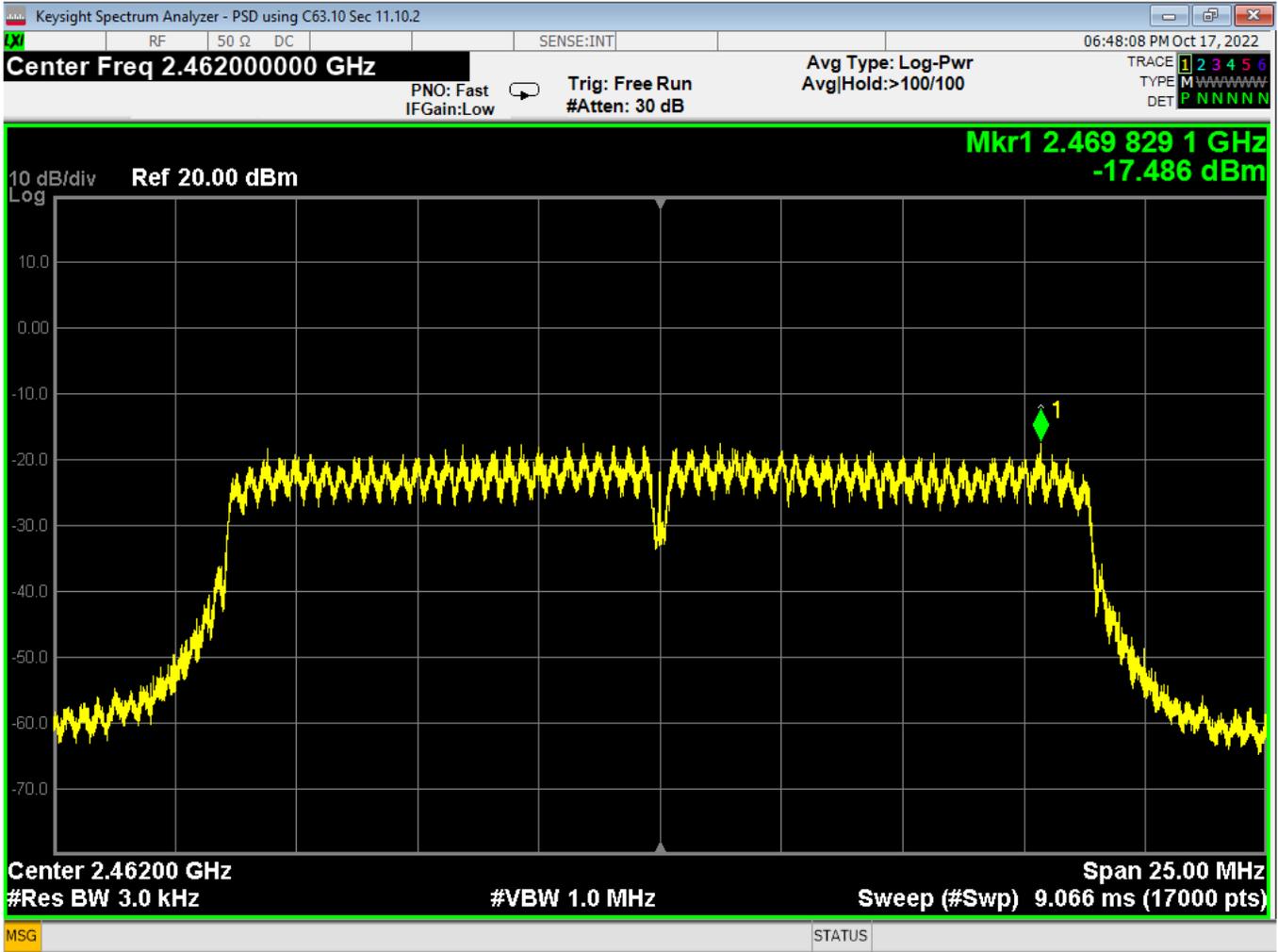
Report Number:	R20220901-21-E5A	Rev	A
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73 PSD, Mid, Wifi N, High Data Rate



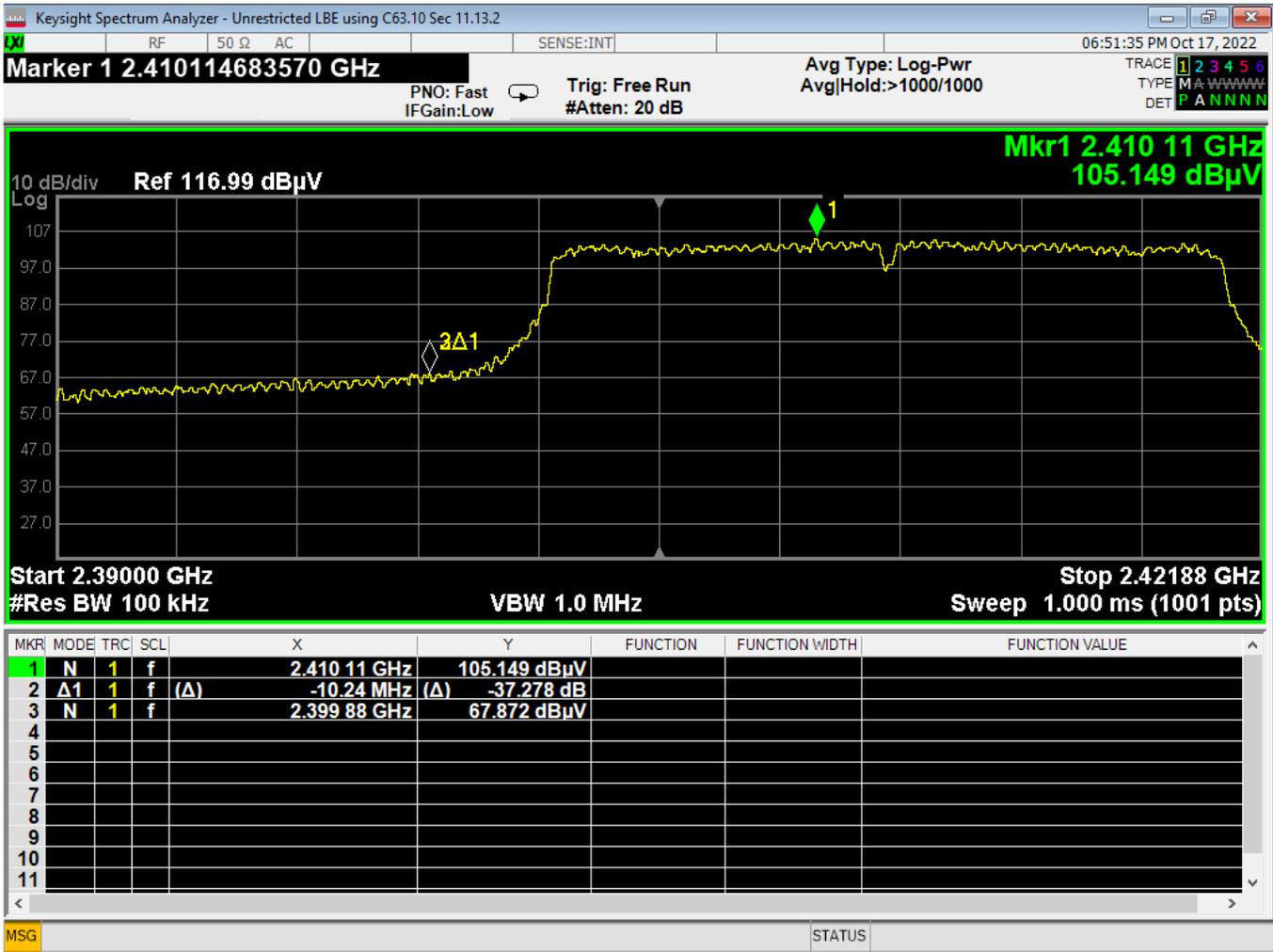
Report Number:	R20220901-21-E5A	Rev	A
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74 PSD, High, Wifi N, High Data Rate



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75 Lower Bandedge, Unrestricted, Wifi N, High Data Rate



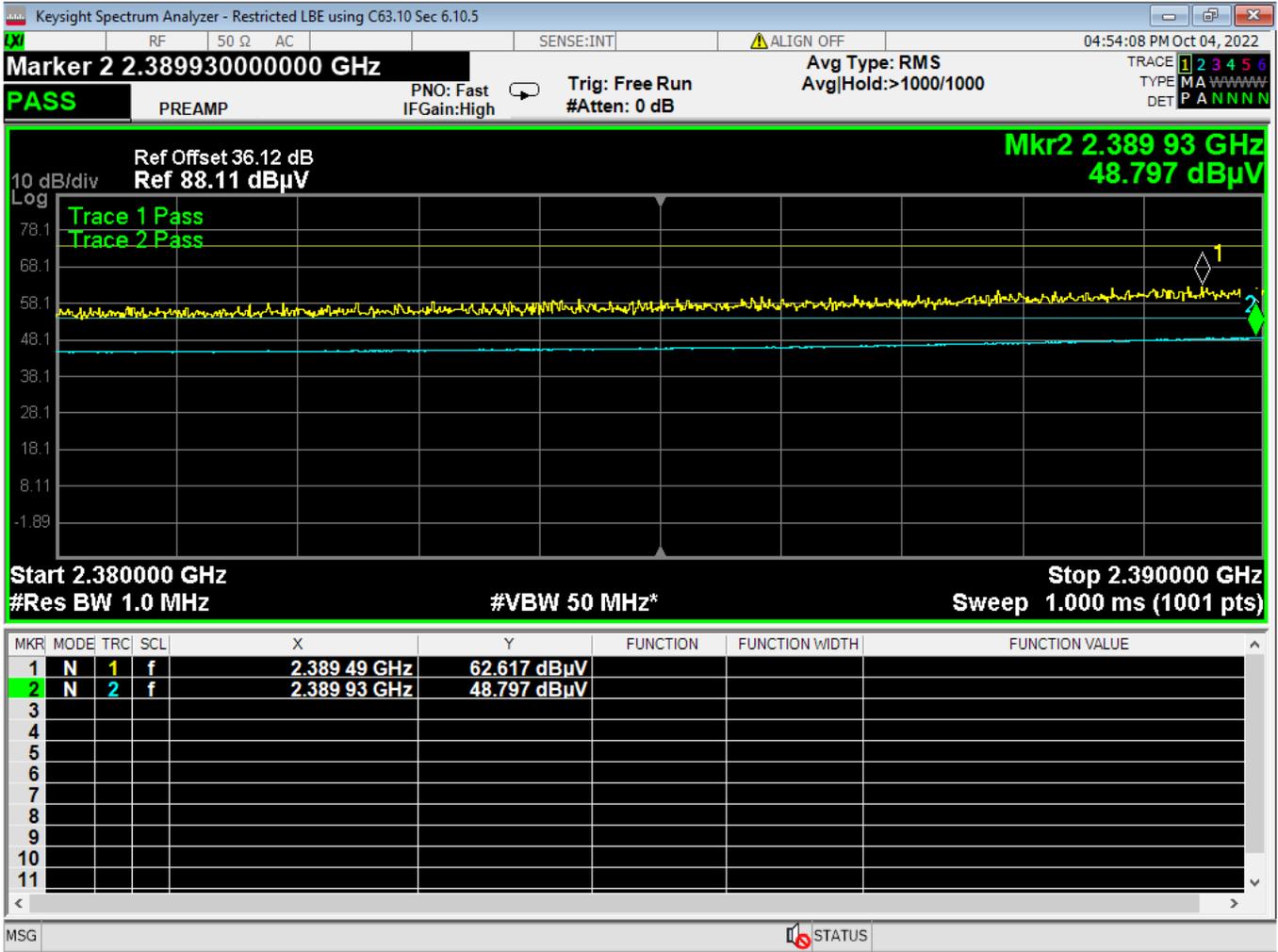
Report Number:	R20220901-21-E5A	Rev	A
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76 Higher Bandedge, Unrestricted, Wifi N, High Data Rate



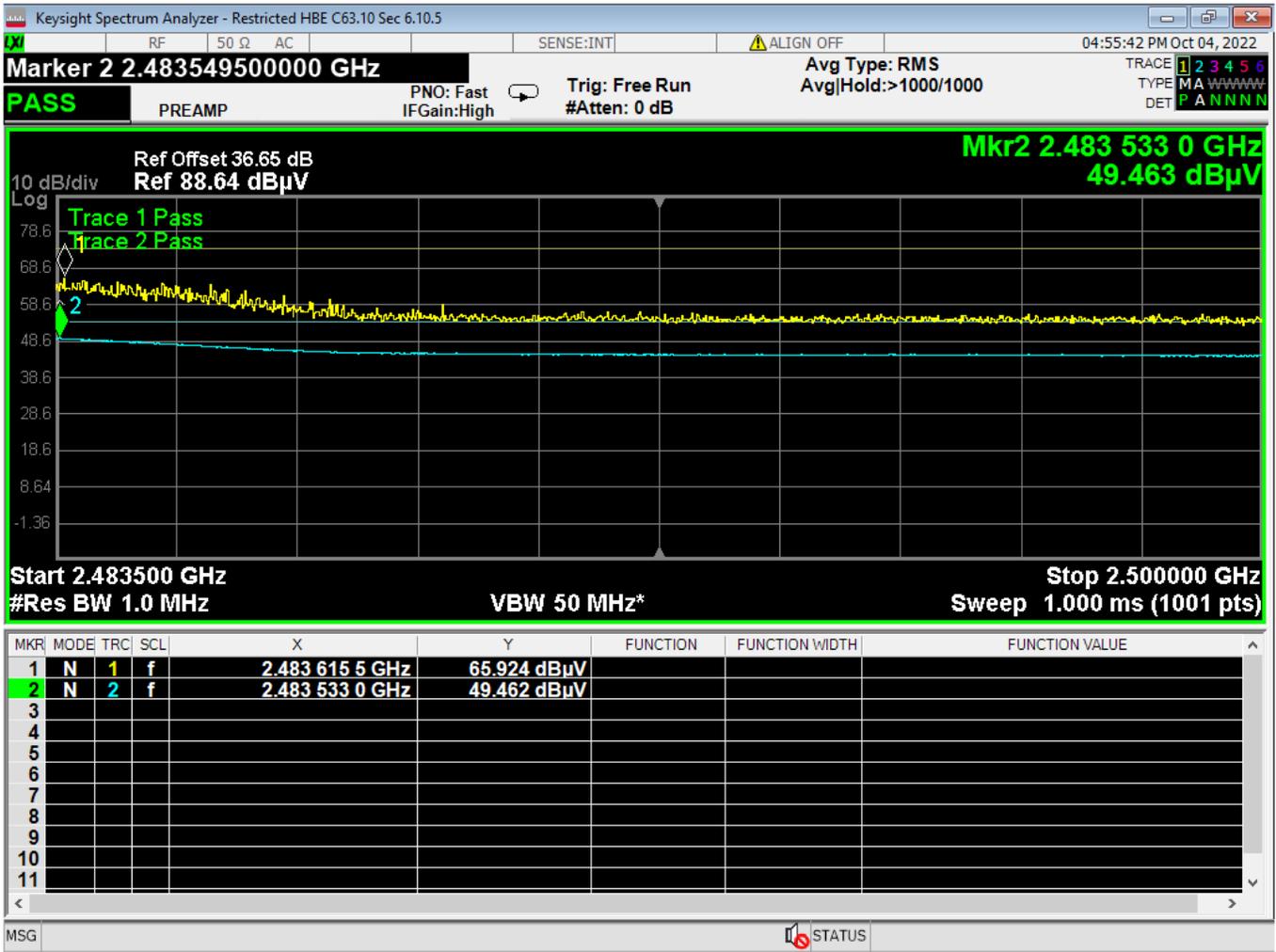
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



77 Lower Bandedge, Restricted, Wifi N, High Data Rate



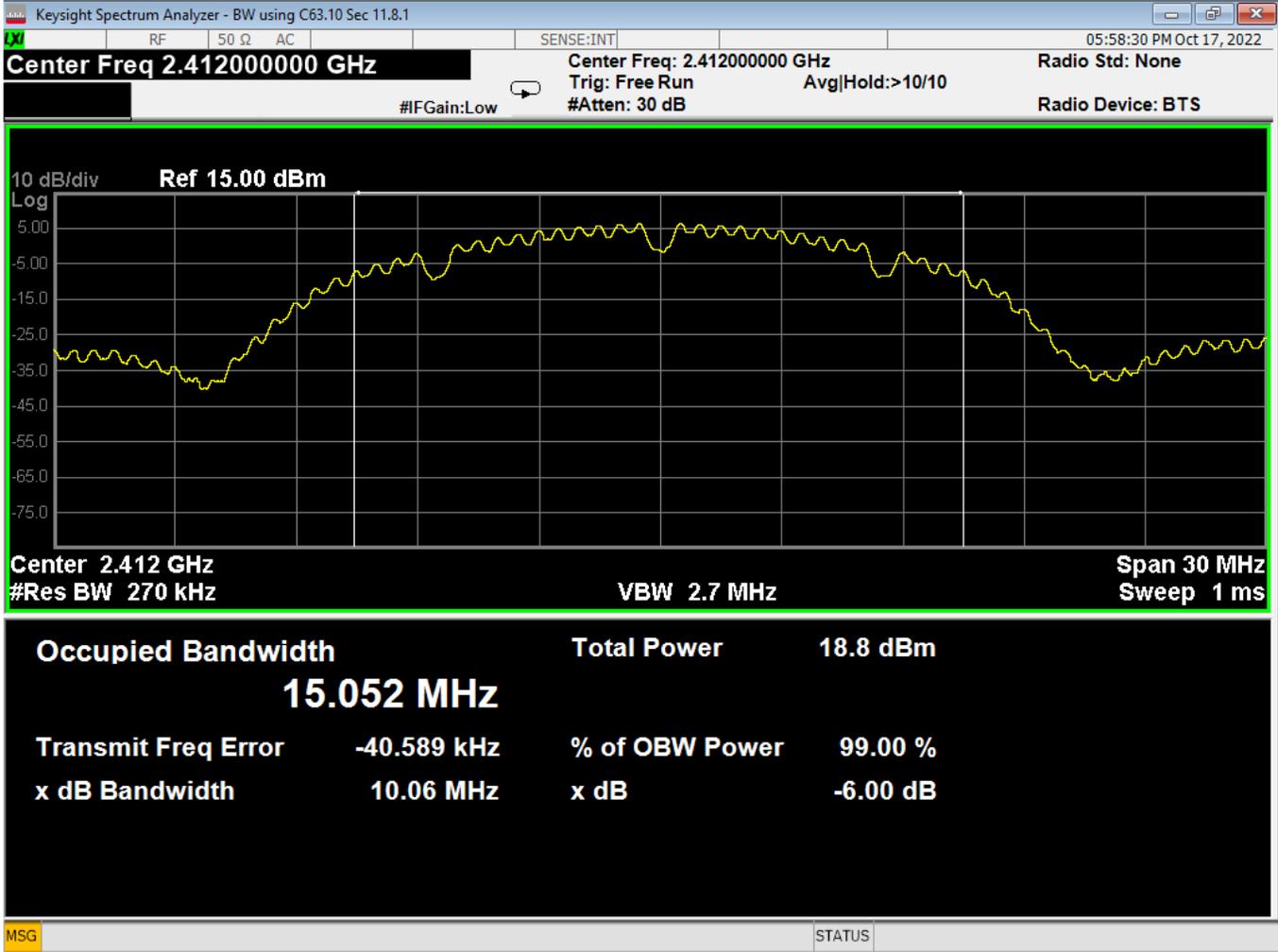
Report Number:	R20220901-21-E5A	Rev	A
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78 Higher Bandedge, Restricted, Wifi N, High Data Rate



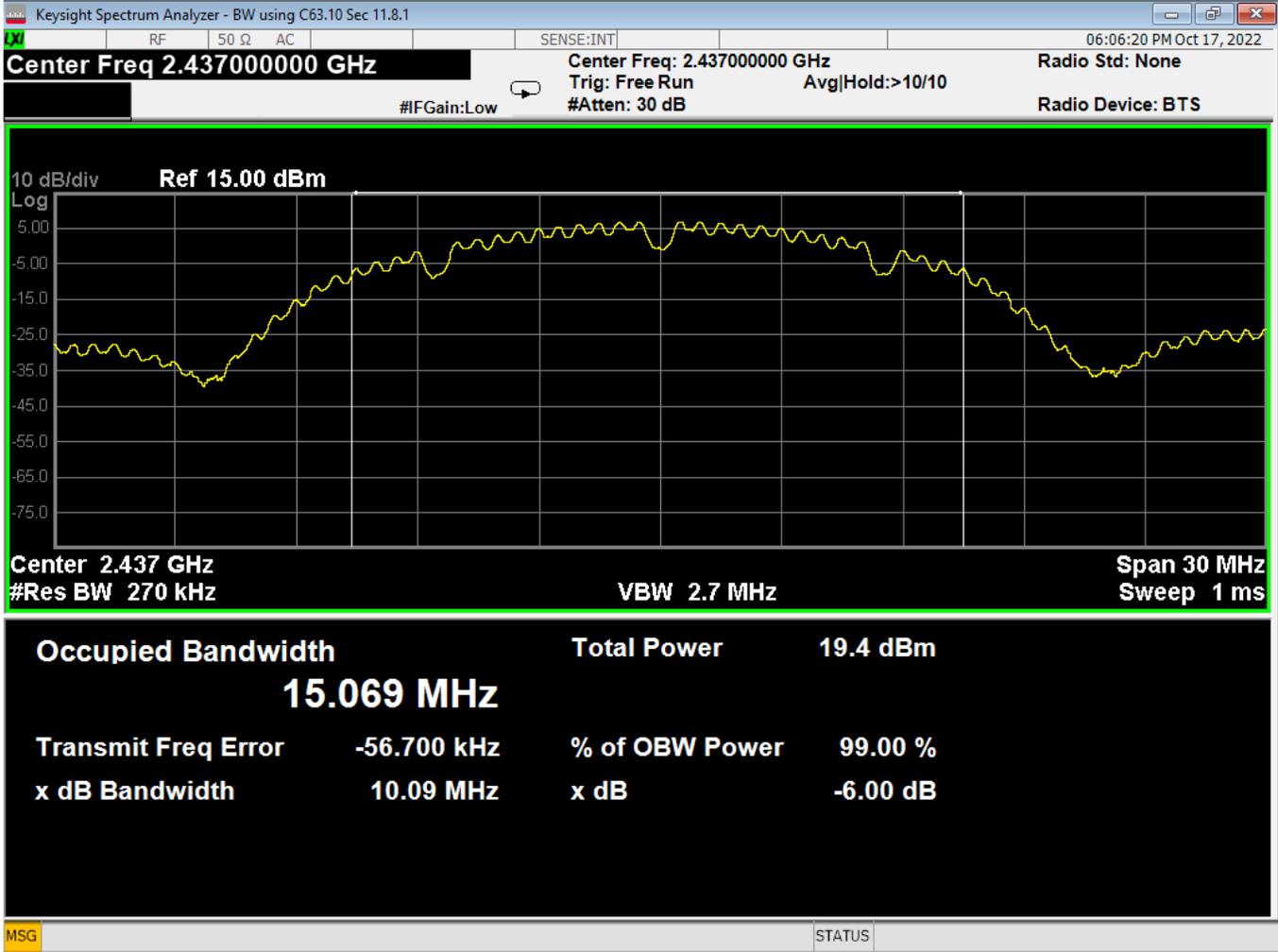
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



79 Occupied Bandwidth, Low, Wifi B, Low Data Rate



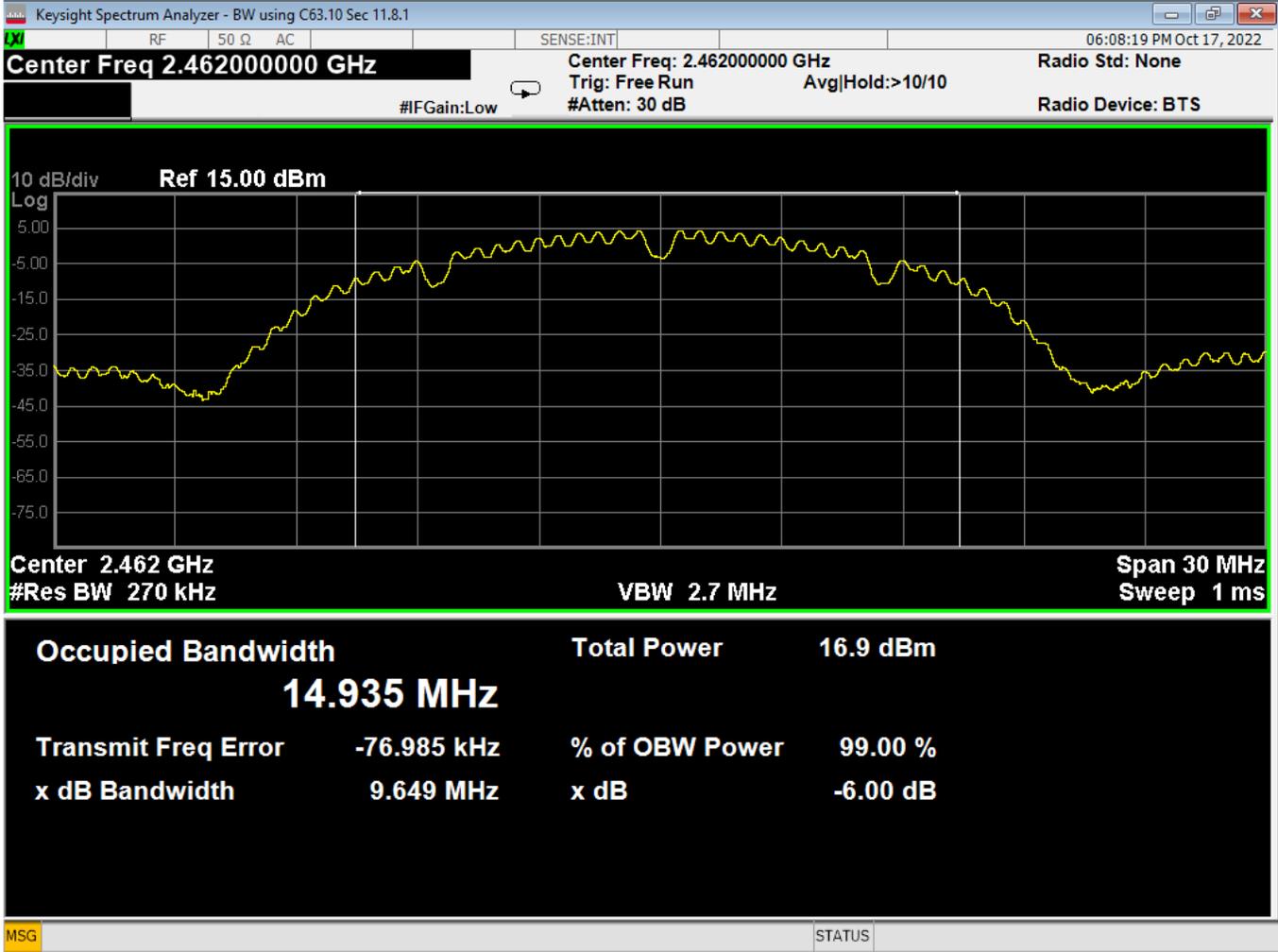
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



80 Occupied Bandwidth, Mid, Wifi B, Low Data Rate



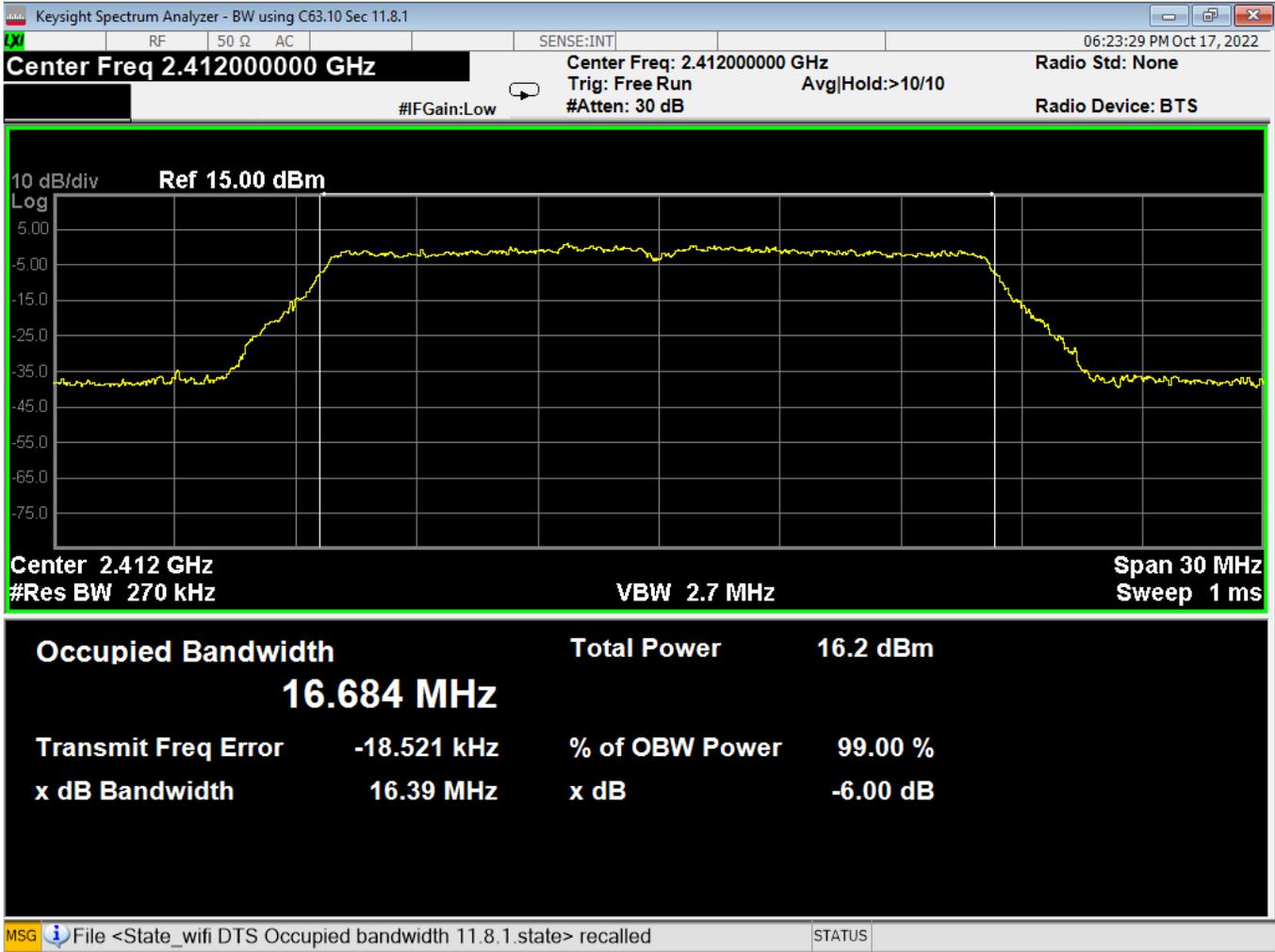
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



81 Occupied Bandwidth, High, Wifi B, Low Data Rate



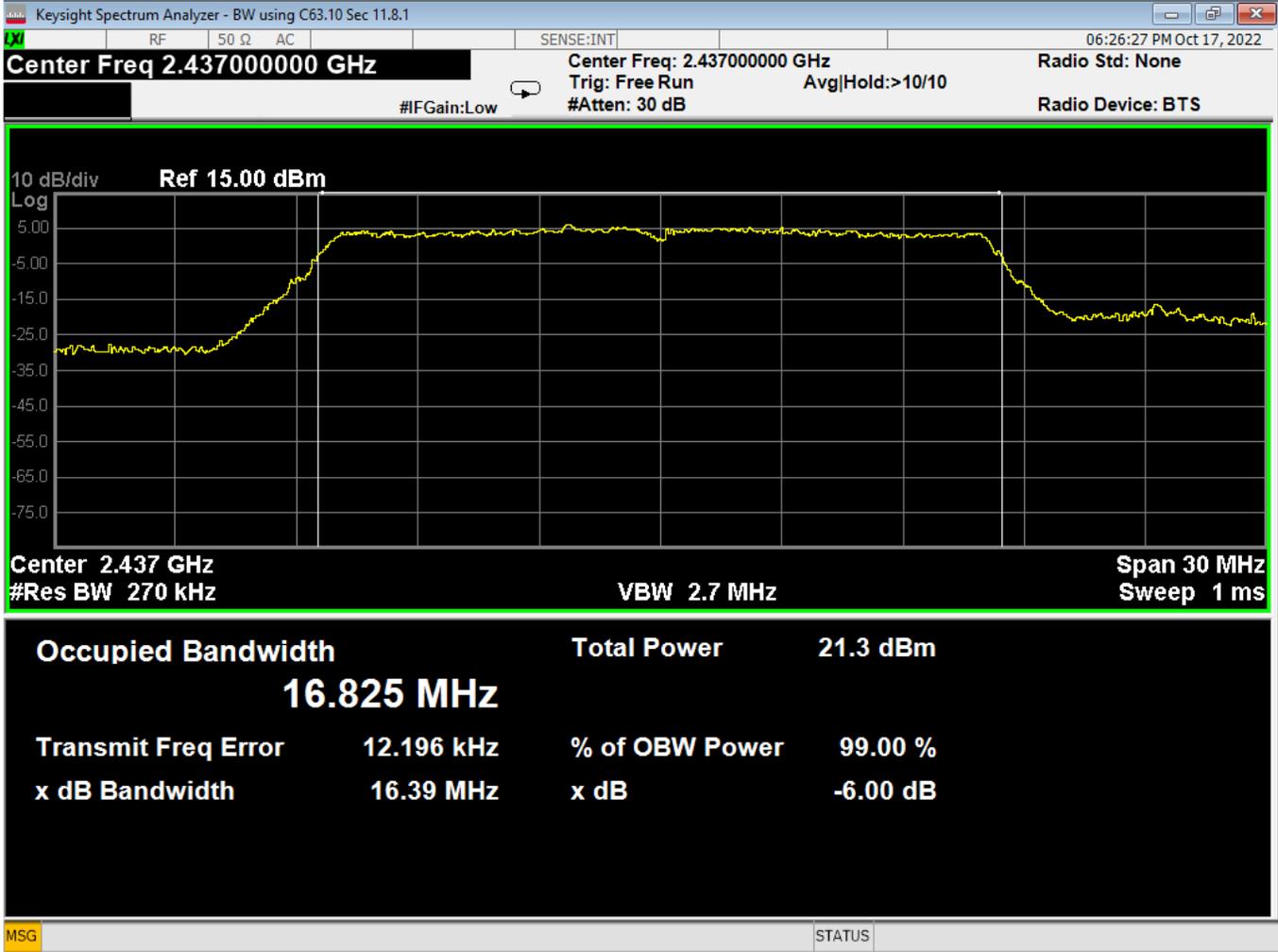
Report Number:	R20220901-21-E5A	Rev	A
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82 Occupied Bandwidth, Low, Wifi G, Low Data Rate



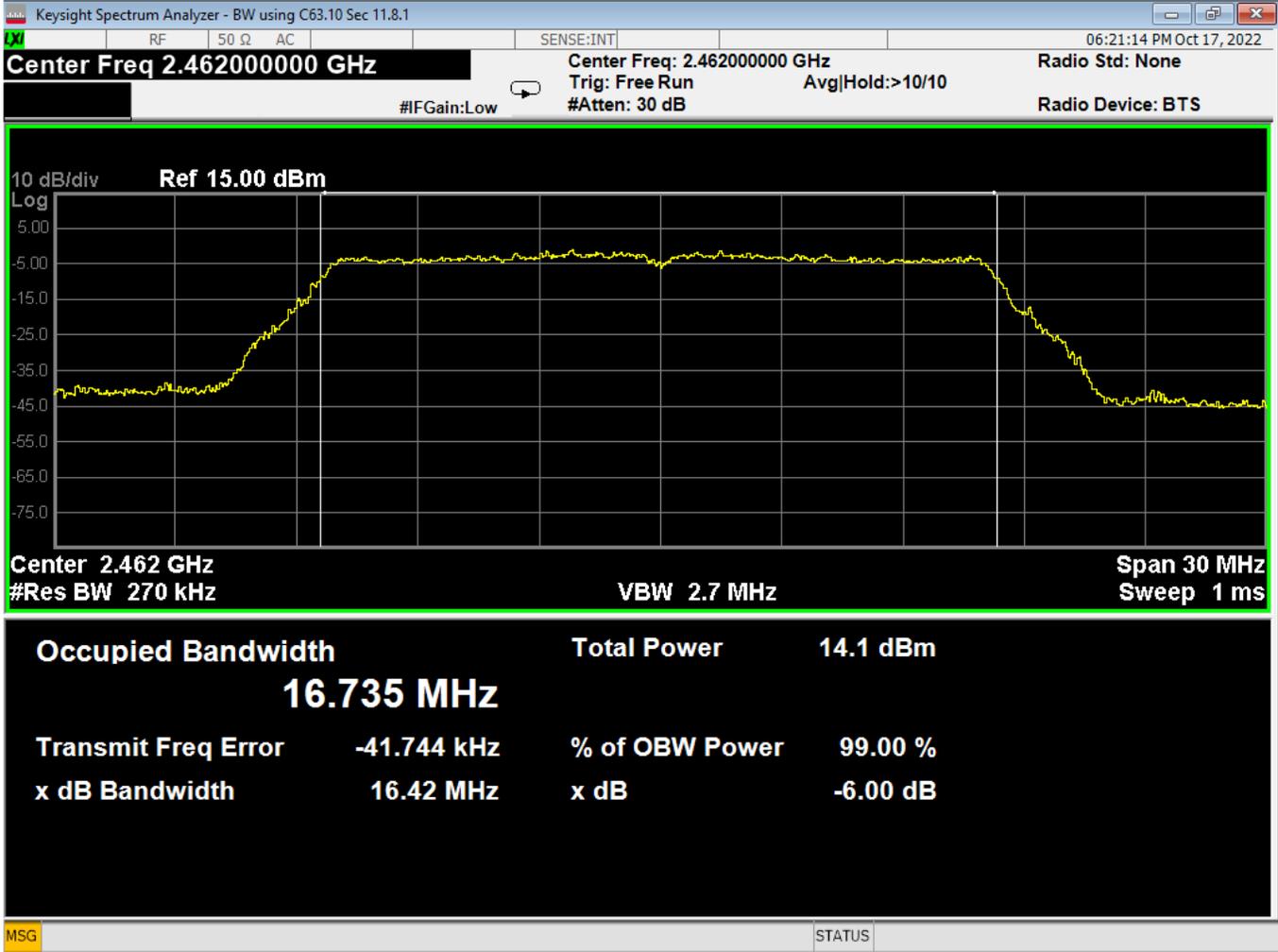
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



83 Occupied Bandwidth, Mid, Wifi G, Low Data Rate



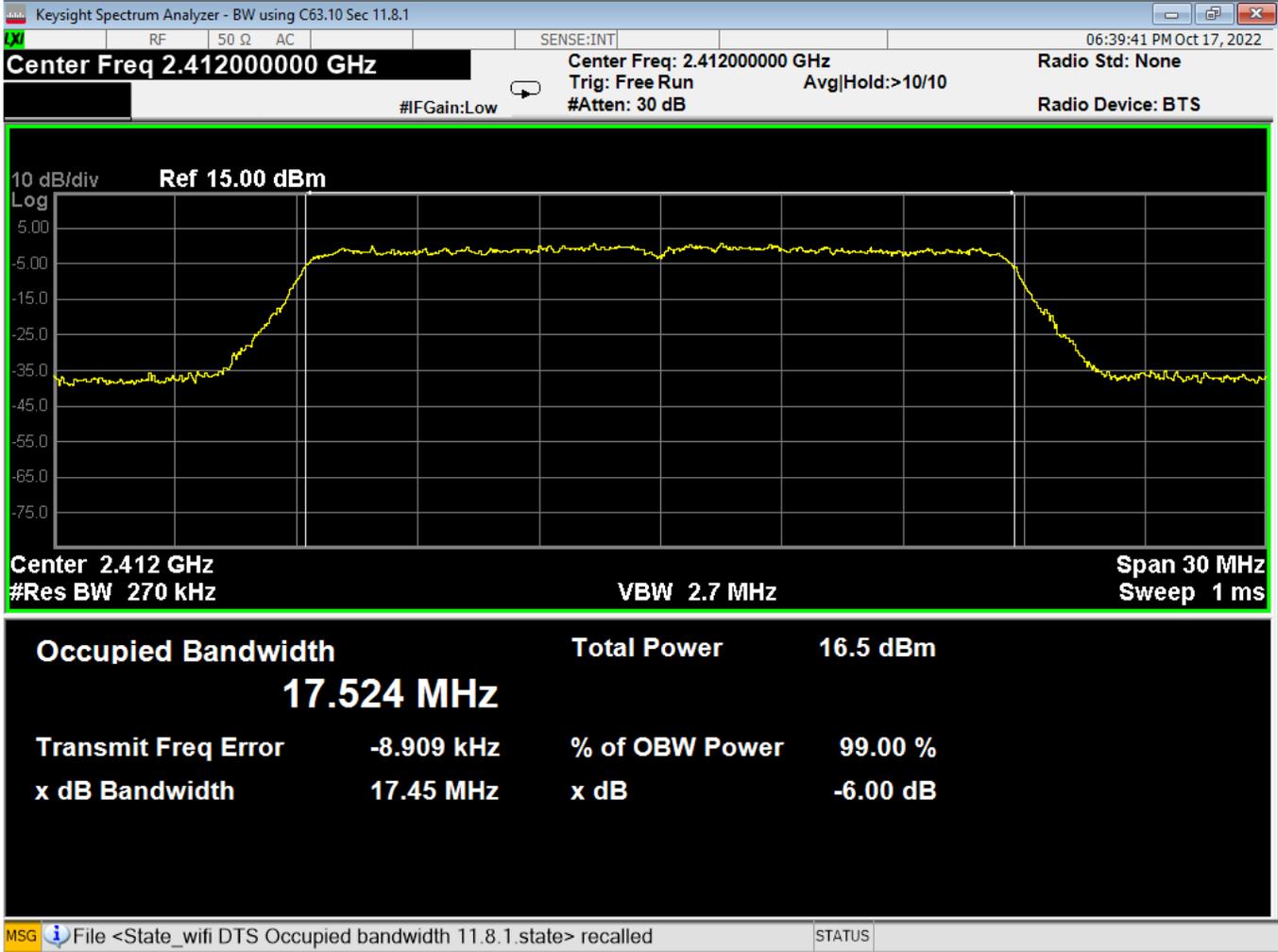
Report Number:	R20220901-21-E5A	Rev	A
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84 Occupied Bandwidth, High, Wifi G, Low Data Rate



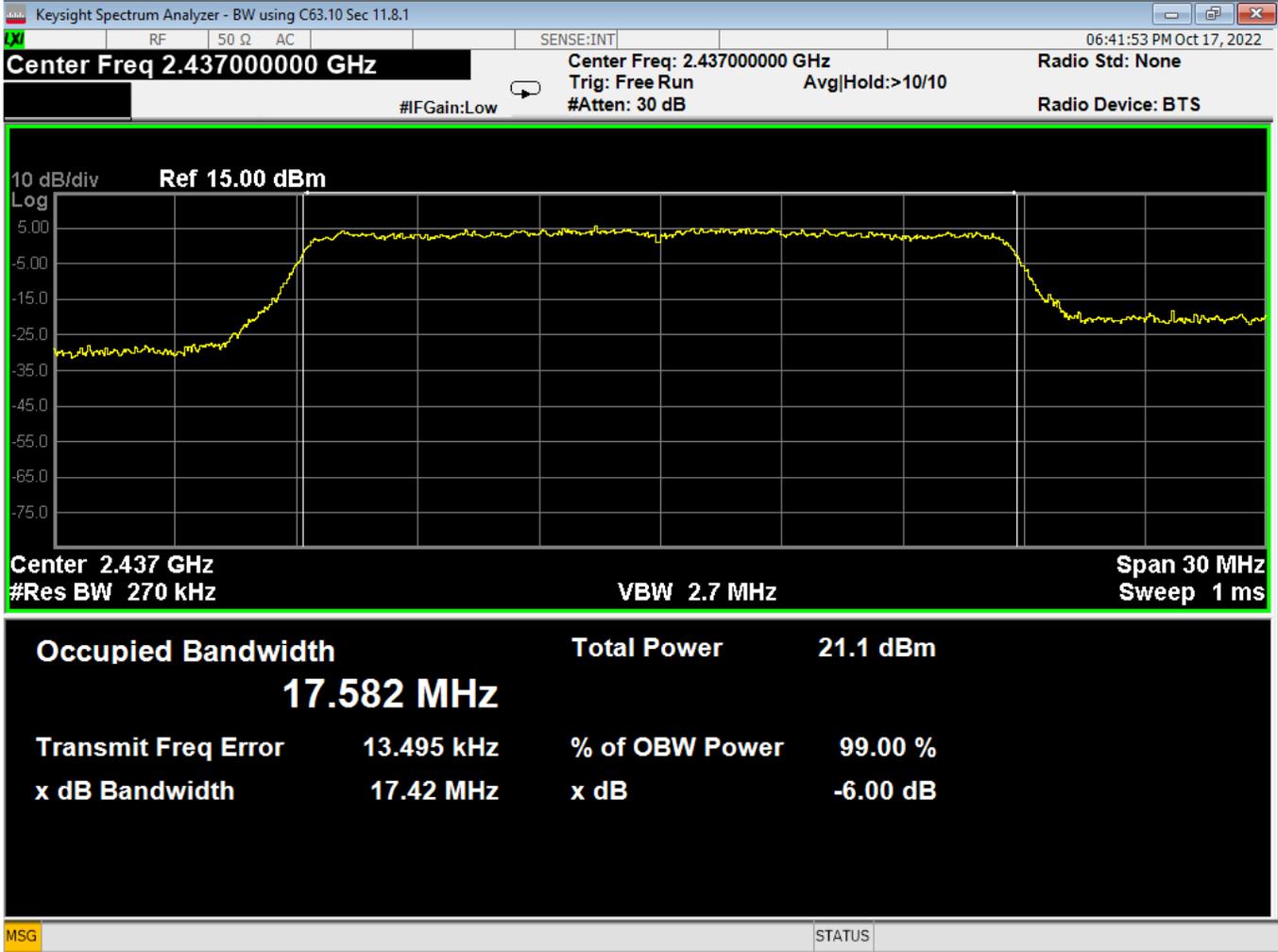
Report Number:	R20220901-21-E5A	Rev	A
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85 Occupied Bandwidth, Low, Wifi N, Low Data Rate



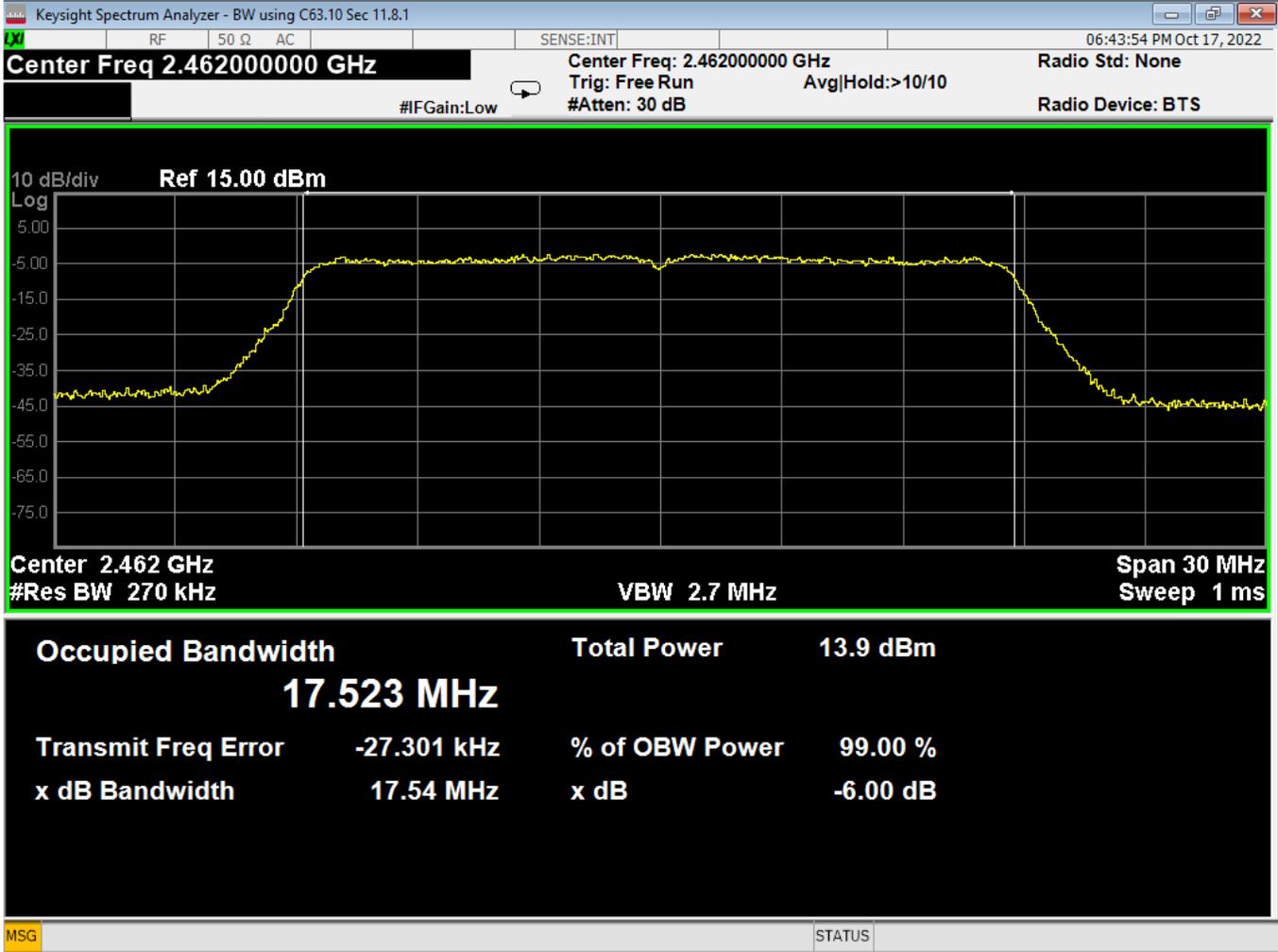
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



86 Occupied Bandwidth, Mid, Wifi N, Low Data Rate



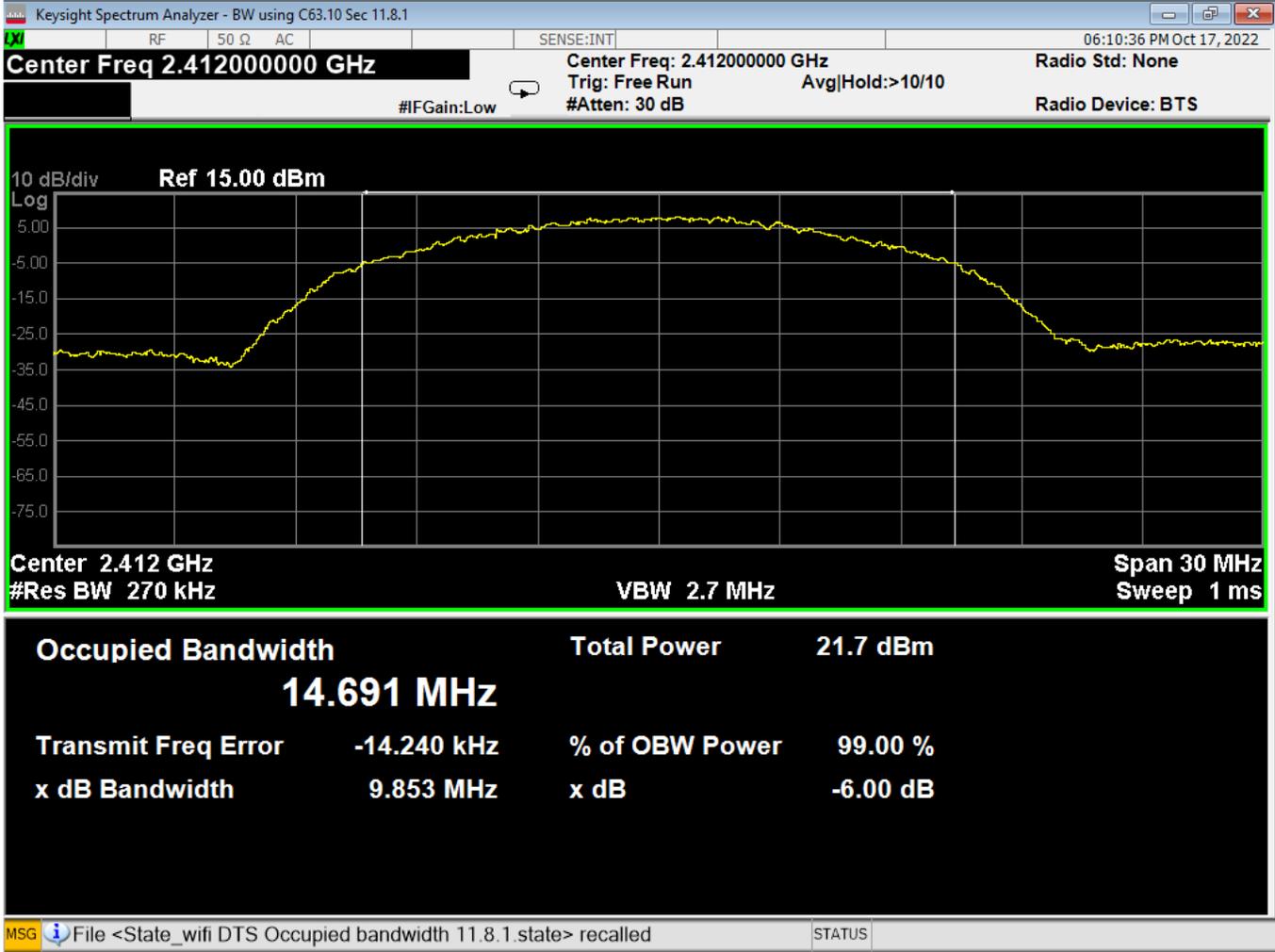
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



87 Occupied Bandwidth, High, Wifi N, Low Data Rate



Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		

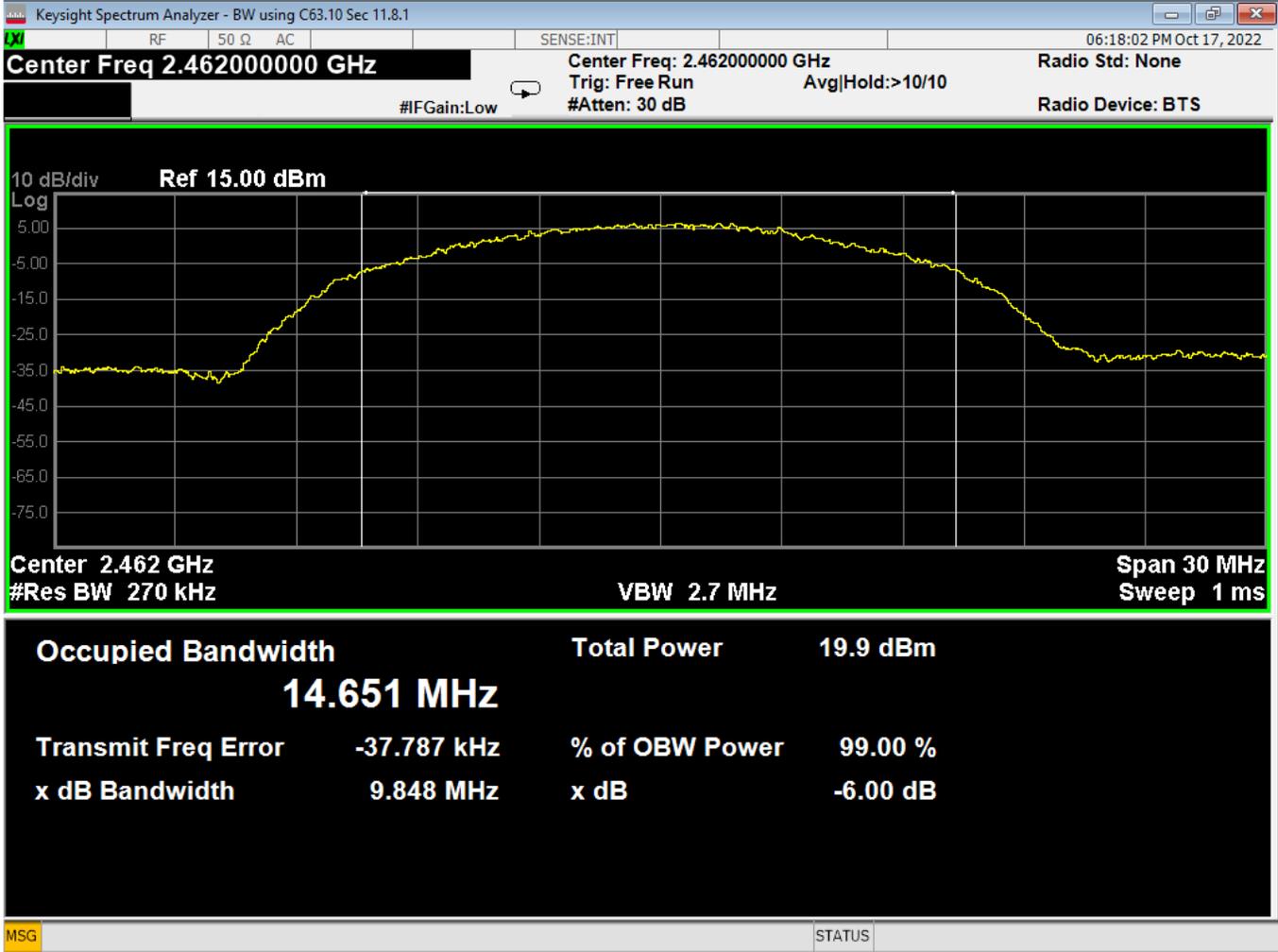


88 Occupied Bandwidth, Low, Wifi B, High Data Rate





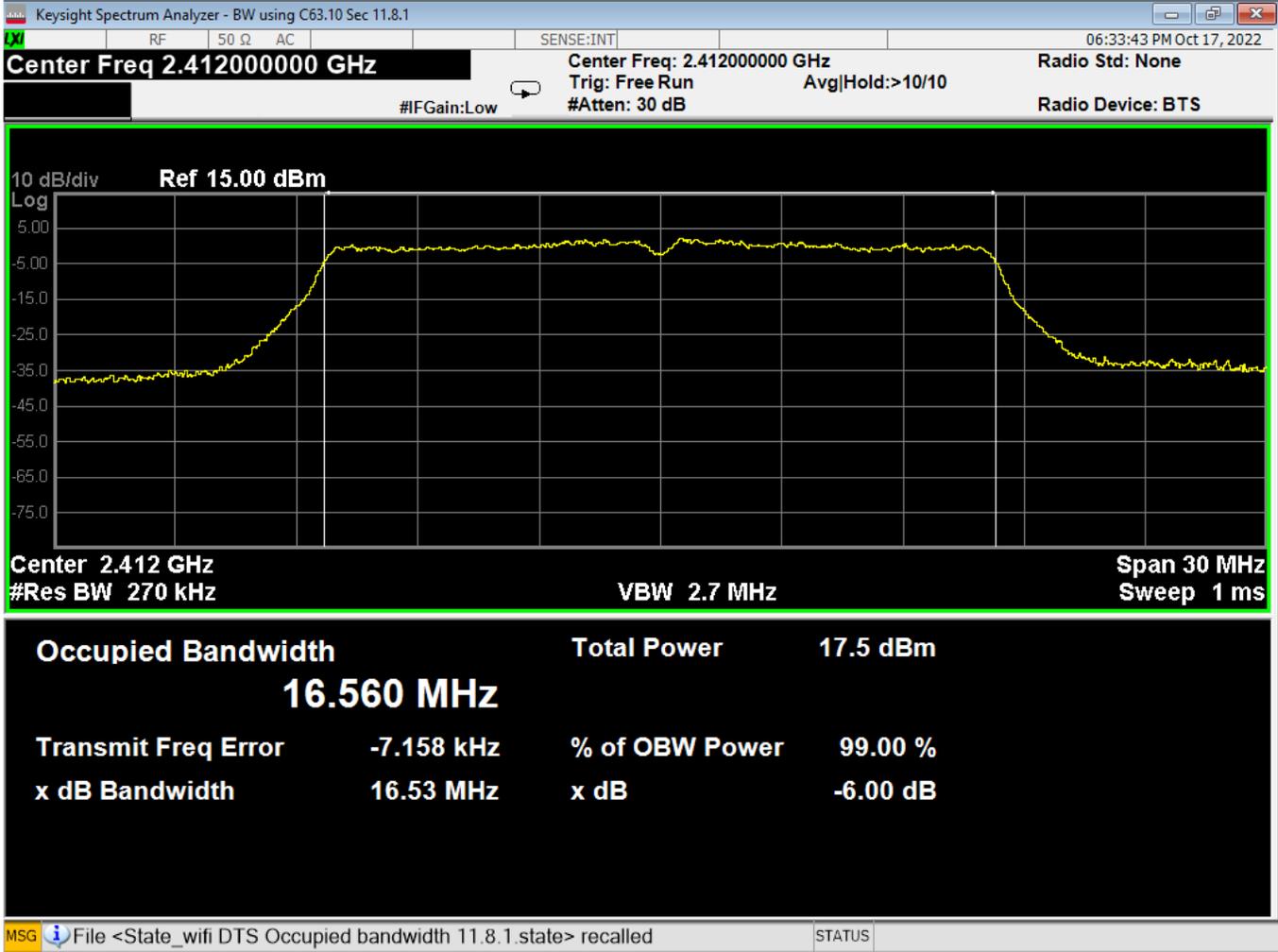
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



90 Occupied Bandwidth, High, Wifi B, High Data Rate



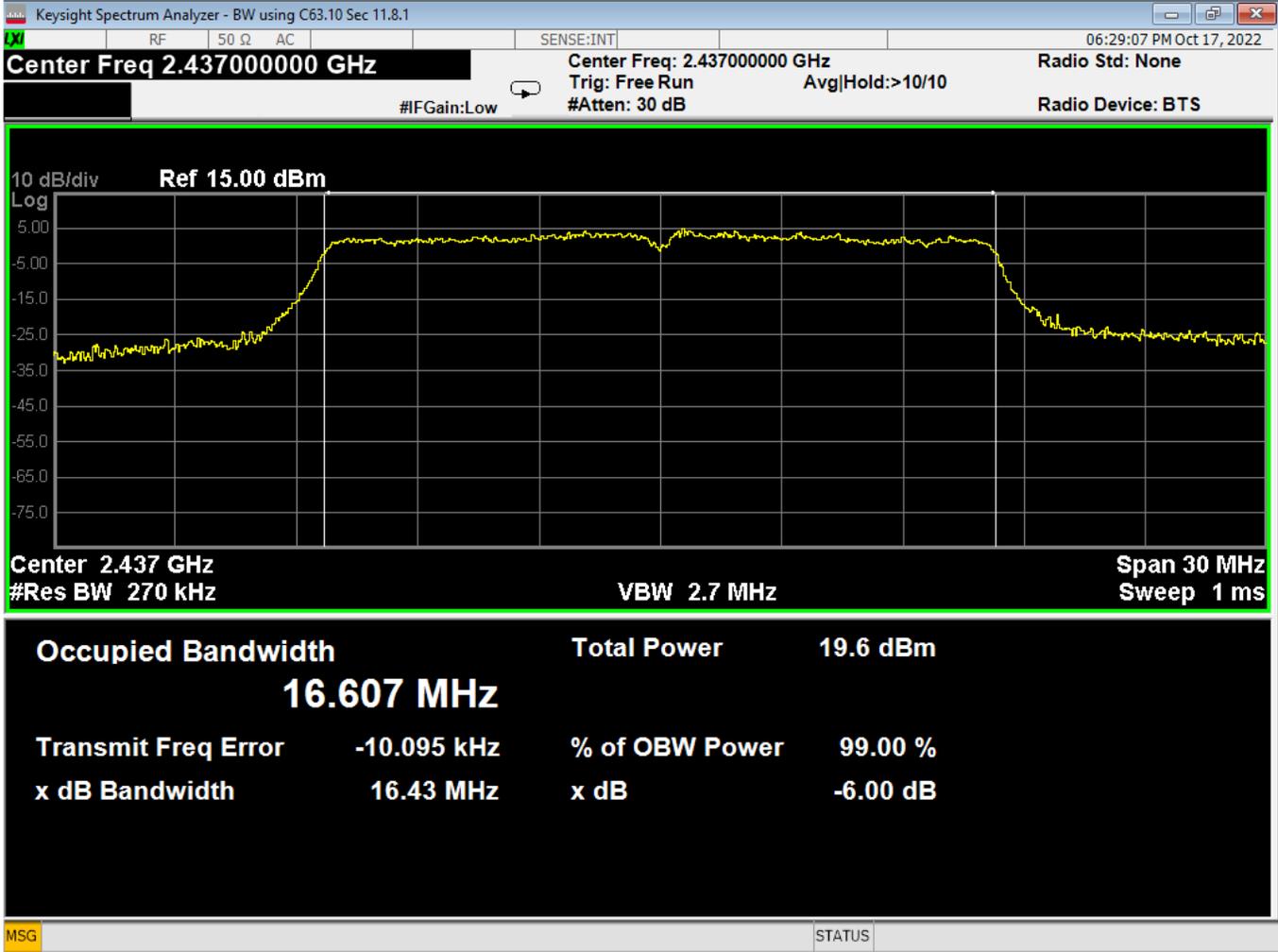
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



91 Occupied Bandwidth, Low, Wifi G, High Data Rate



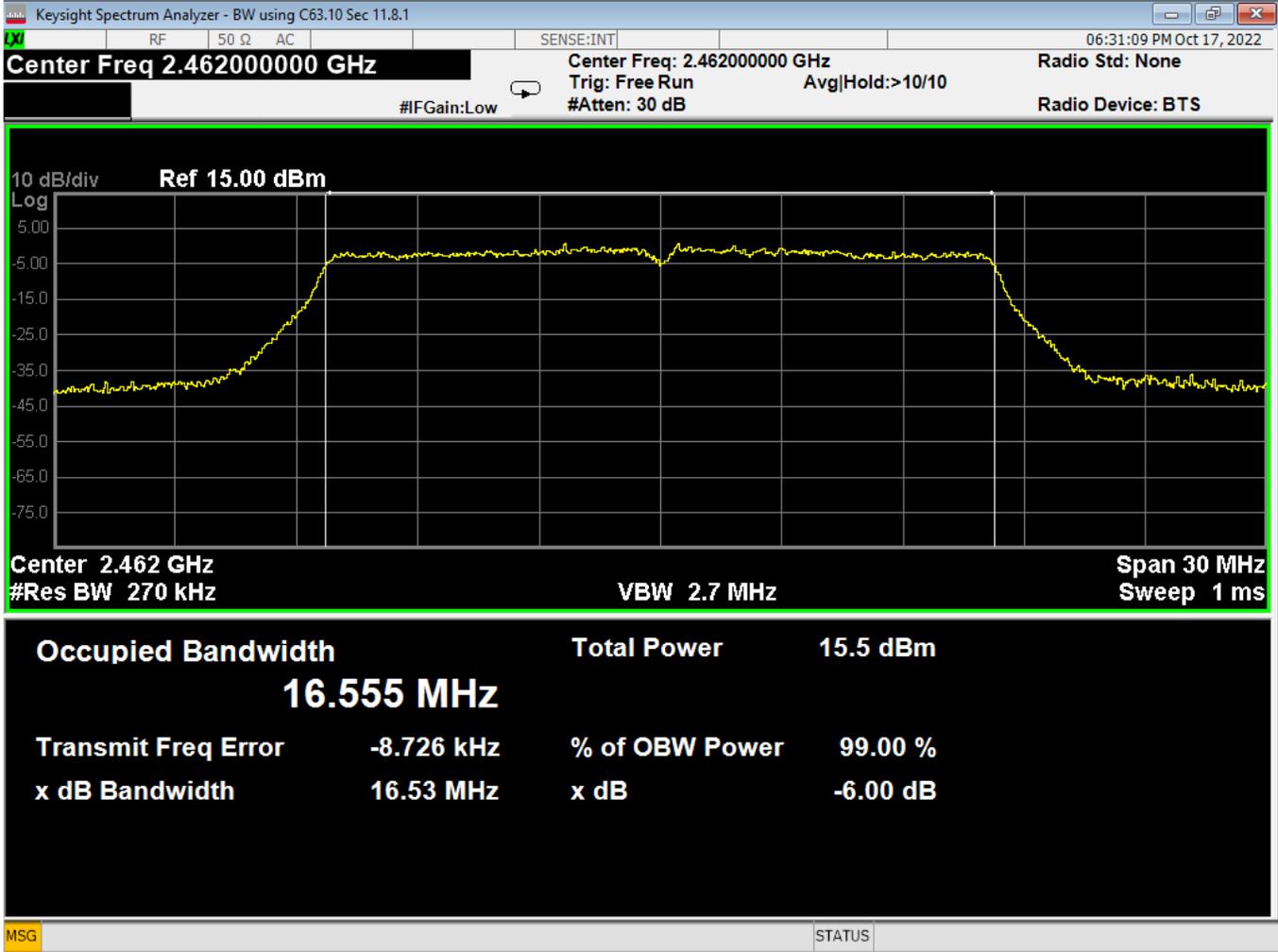
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



92 Occupied Bandwidth, Mid, Wifi G, High Data Rate



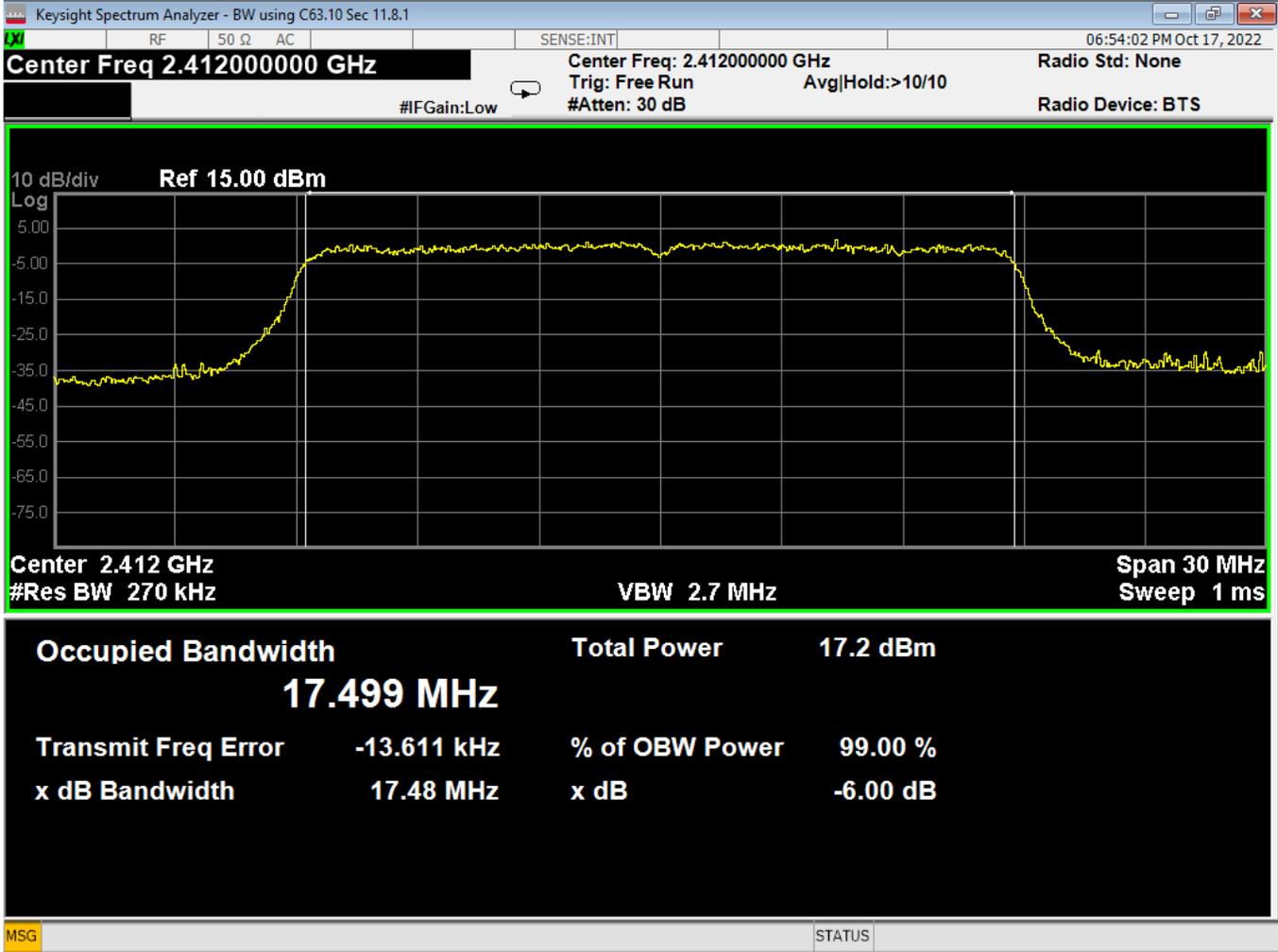
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



93 Occupied Bandwidth, High, Wifi G, High Data Rate



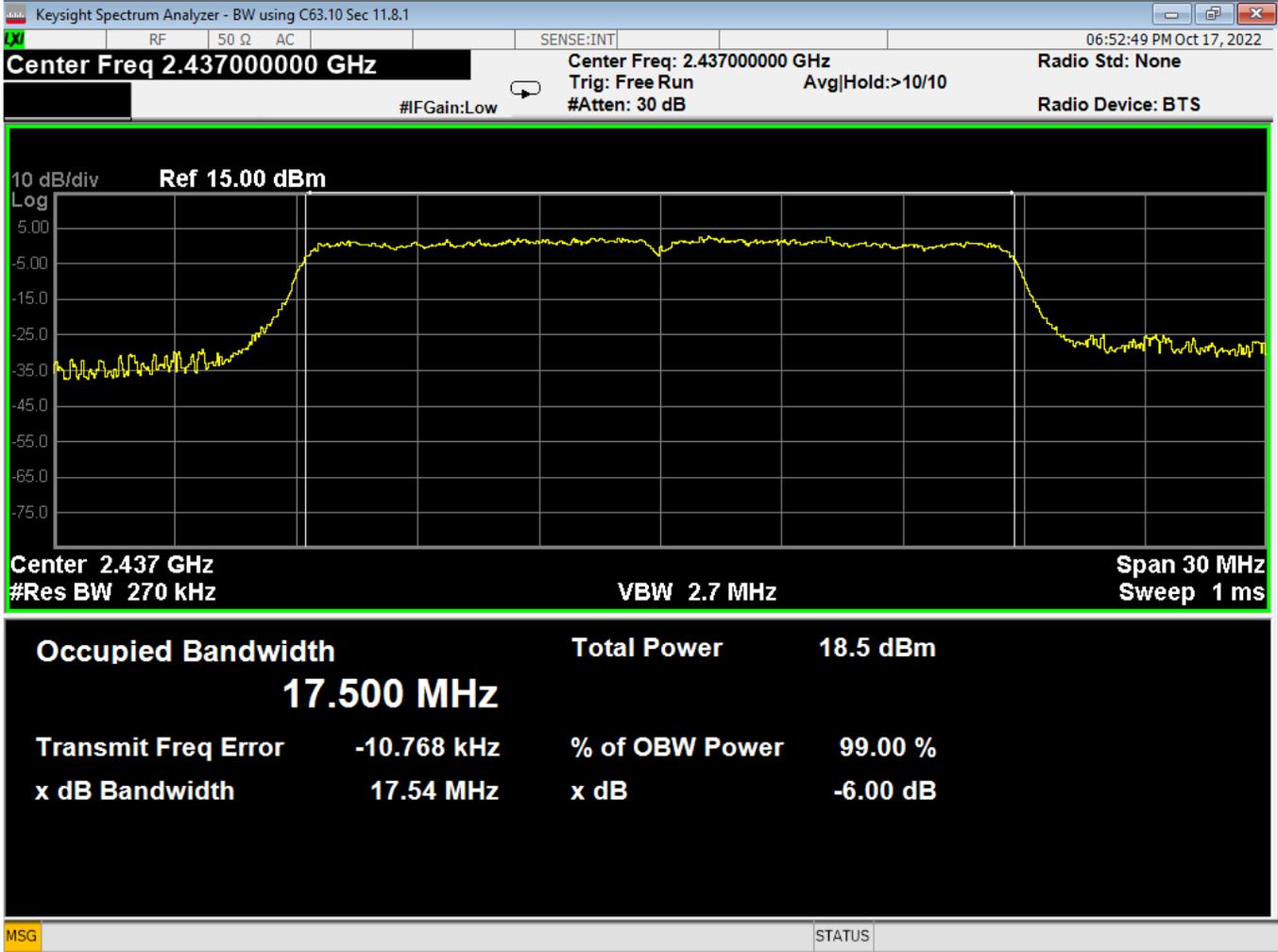
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



94 Occupied Bandwidth, Low, Wifi N, High Data Rate



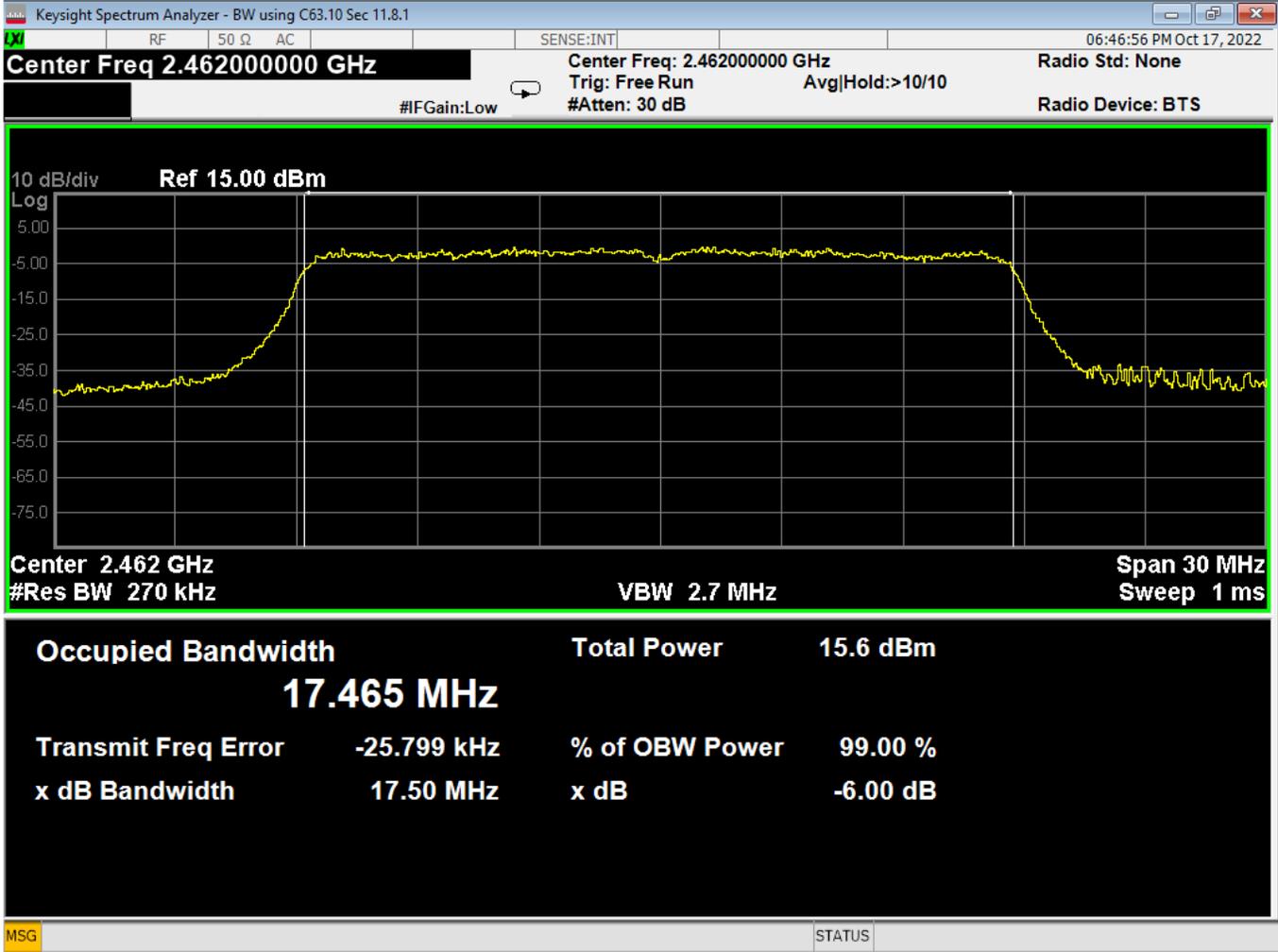
Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



95 Occupied Bandwidth, Mid, Wifi N, High Data Rate



Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		



96 Occupied Bandwidth, High, Wifi N, High Data Rate



Report Number:	R20220901-21-E5A	Rev	A
Prepared for:	Garmin International, Inc.		

REPORT END

## FCC/ISED Test Report

**Prepared for:** Garmin International, Inc.

**Address:** 1200 E. 151<sup>st</sup> Street  
Olathe, Kansas, 66062, USA

**Product:** A04452

**Test Report No:** R20220901-21-E19B

**Approved by:**



Fox Lane,  
EMC Test Engineer

**DATE:** December 6, 2022

**Total Pages:** 27

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Prepared for:	Garmin International, Inc.		

**REVISION PAGE**

Rev. No.	Date	Description
0	22 November 2022	Issued – FLane Reviewed by KVepuri Prepared by FLane
A	30 November 2022	Corrected Table 2 to reflect transmitter tested - FL
B	6 December 2022	Removed Antenna Gain - FL



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## 1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section:

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15.249
- (2) ISED RSS-Gen, Issue 5
- (3) ISED RSS-210, Issue 10

APPLIED STANDARDS AND REGULATIONS		
Standard Section	Test Type	Result
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
NA, Informational purpose only	Bandwidth	NA
FCC Part 15.209 RSS-Gen Issue 5, Section 7.3	Receiver Radiated Emissions	Pass
FCC Part 15.209 FCC 15.249(a) RSS-210 Issue 10, Annex F.1(a) RSS-Gen Issue 5, Section 6.13	Transmitter Radiated Emissions	Pass
FCC Part 15.209, 15.249(d) RSS-210 Issue 10 Annex F.1(e) RSS-Gen Issue 5, Section 6.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass



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## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

#### Summary and Operating Condition:

<b>EUT</b>	A04453
<b>IC</b>	1792A-04452
<b>FCC ID</b>	IPH-04452
<b>EUT Received</b>	3 October 2022
<b>EUT Tested</b>	3 October 2022- 7 November 2022
<b>Serial No.</b>	3426283485 (Radiated Measurements) 3426283465 (Conducted Measurements)
<b>Operating Band</b>	2400 – 2483.5 MHz
<b>Device Type</b>	<input type="checkbox"/> GMSK <input checked="" type="checkbox"/> GFSK <input type="checkbox"/> BT BR <input type="checkbox"/> BT EDR 2MB <input type="checkbox"/> BT EDR 3MB <input type="checkbox"/> 802.11x
<b>Power Supply / Voltage</b>	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: AQ27A-59CFA GPN: 362-00118-00 (Representative Power Supply)

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

### 2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

GFSK Transmissions

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

### 2.3 DESCRIPTION OF SUPPORT UNITS

None

### 3.0 LABORATORY AND GENERAL TEST DESCRIPTION

#### 3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)  
 4740 Discovery Drive  
 Lincoln, NE 68521  
 A2LA Certificate Number: 1953.01  
 FCC Accredited Test Site Designation No: US1060  
 Industry Canada Test Site Registration No: 4294A  
 NCC CAB Identification No: US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of 35 ± 4%  
 Temperature of 22 ± 3° Celsius



#### 3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Review/Testing and Report
2	Blake Winter	Test Engineer	Testing
3	Grace Larsen	Test Engineer	Testing and Report
4	Ethan Schmidt	Test Technician	Testing

**Notes:** All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.



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### 3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
ETS EMCO Red Horn Antenna	3115	00218655	July 21, 2022	July 21, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preampfier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Rohde & Schwarz Preampfier*	TS-PR18	3545700803	August 22, 2022	August 22, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber***	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preampfier to antenna)*	MFR-57500	90-195-040	August 22, 2022	August 22, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

\*Internal Characterization

\*\*2 Year Cal Cycle

\*\*\*3 Year Cal Cycle

**Notes:**

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

### 3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMENTS

Measurement type presented in this report (Please see the checked box below):

#### Conducted

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

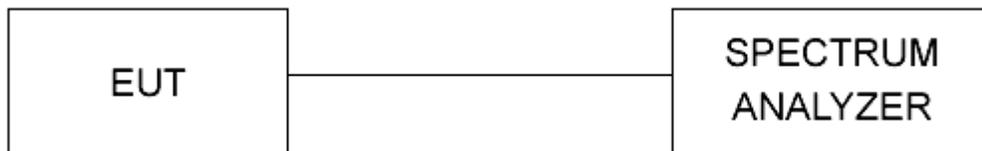


Figure 1 - Bandwidth Measurements Test Setup

#### Radiated

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

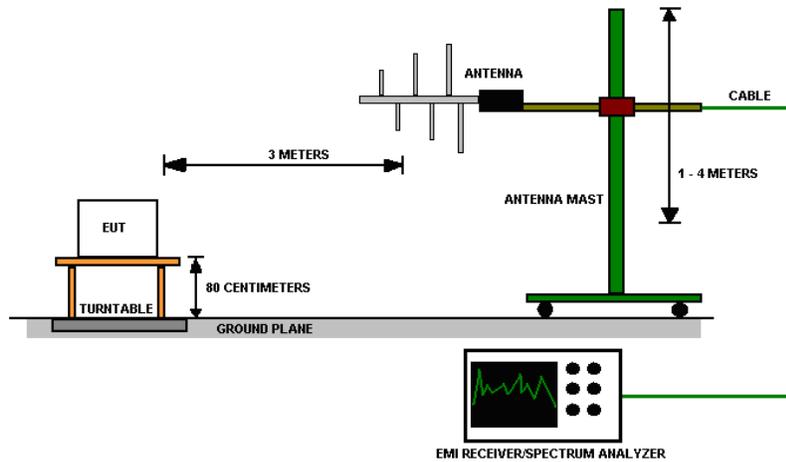


Figure 2 - Radiated Emissions Test Setup



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#### 4.0 RESULTS

##### Unrestricted Band-Edge, 50dB Delta

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamental (dBuV)	Delta (dB)	Min Delta (dB)	Result
High	GFSK	2483.50	51.339	103.969	52.630	30	PASS

##### Peak Restricted Band-Edge

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	GFSK	2390.00	53.562	Peak	73.98	20.42	PASS
High	GFSK	2483.50	57.533	Peak	73.98	16.45	PASS

\*Limit shown is the peak limit taken from FCC Part 15.209

##### Average Restricted Band-Edge

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)	Margin	Result
Low	GFSK	2390.00	41.738	Average	53.98	12.24	PASS
High	GFSK	2483.50	48.348	Average	53.98	5.63	PASS

\*Limit shown is the average limit taken from FCC Part 15.209

##### Unrestricted Band-Edge, 15.209 Limits

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Limit (15.209)	Margin	Detector Type	Result
Low	GFSK	2400.00	69.497	73.98	4.483	Peak	PASS
<b>Low</b>	<b>GFSK</b>	<b>2400.00</b>	<b>53.017*</b>	<b>53.98</b>	<b>0.96</b>	<b>Average</b>	<b>PASS</b>

\*Average level calculated from; Average Level = Peak Level + DCCF, see section 4.1 for more details on DCCF



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#### 4.1 DUTY CYCLE

**Test Method:**

Manufacturer declares worst-case real world duty cycle to be 15%

$$DCCF = 20 \cdot \log(0.15) = -16.48\text{dB}$$

## 4.2 RADIATED EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.5, 6.6

**Limits for radiated emissions measurements:**

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ( $\mu\text{V/m}$ )	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

**NOTE:**

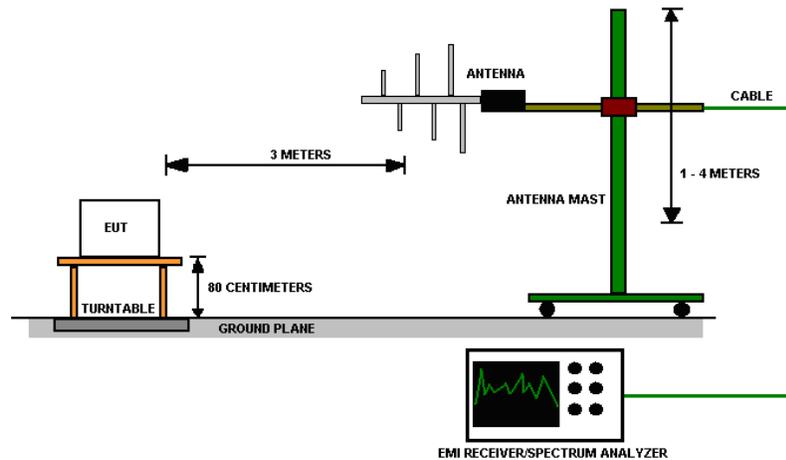
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) =  $20 * \log * \text{Emission level } (\mu\text{V/m})$ .
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.



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Prepared for:	Garmin International, Inc.		

**Test procedures:**

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

**Test setup:**

**Figure 3 - Radiated Emissions Test Setup**
**NOTE:**

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

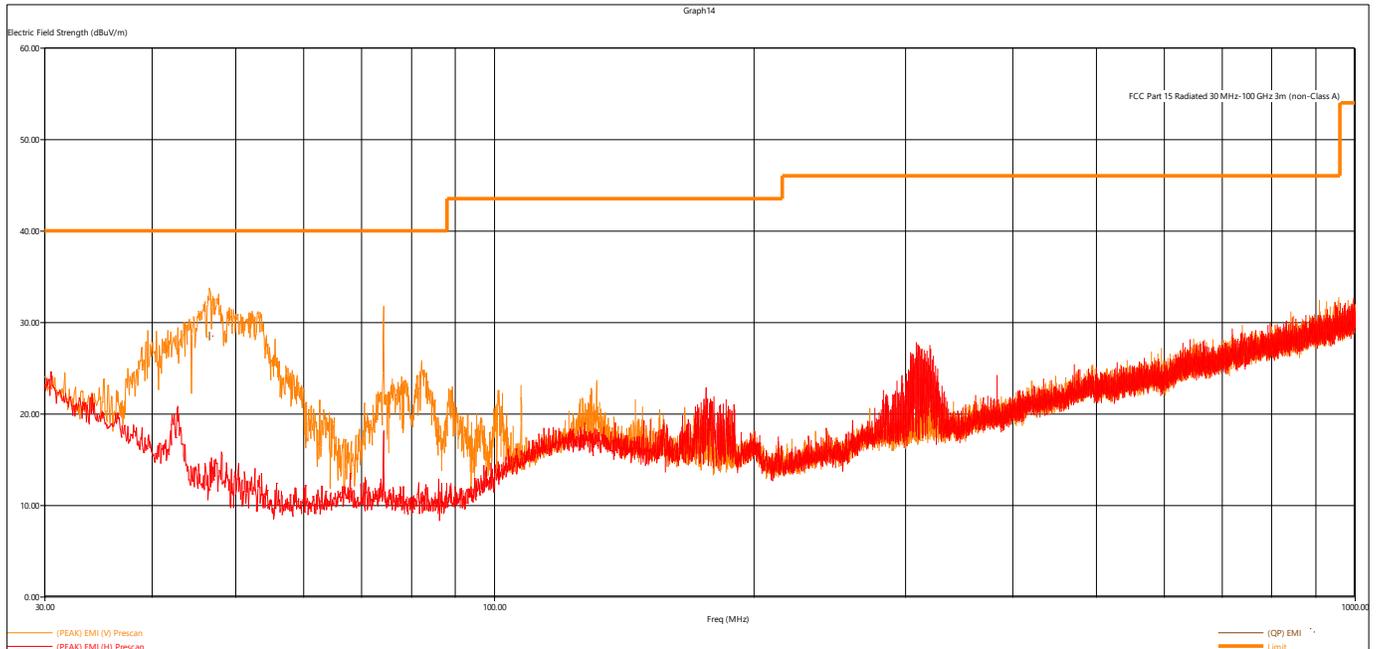
**Deviations from test standard:**

No deviation.

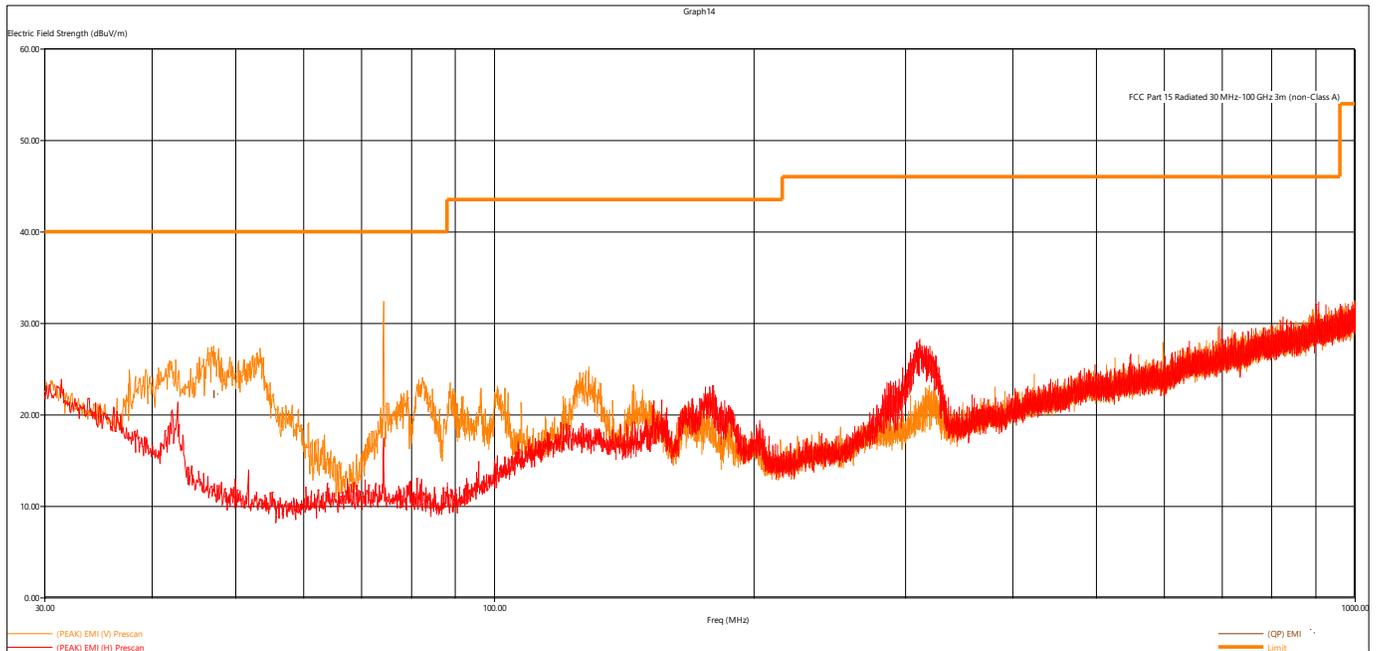
**EUT operating conditions**

Details can be found in section 2.1 of this report.

**Test results:**



**Figure 4 - Radiated Emissions Plot, Receive**



**Figure 5 - Radiated Emissions Plot, GFSK**

**REMARKS:**

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value - Emission level



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Quasi-Peak Measurements, GMSK-GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
47.328240	22.22	40.00	17.78	112.00	165.00	V	Low	GFSK
46.431840	28.41	40.00	11.59	106.00	235.00	V	RX	

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above.  
All other measurements were found to be at least 6 dB below the limit.

Peak Measurements, GMSK-GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2401.740000	96.52	114.00	17.48	120.00	7.00	V	Low	GFSK
2439.690000	100.57	114.00	13.43	187.00	2.00	V	Mid	GFSK
2479.624000	97.95	114.00	16.05	174.00	8.00	V	High	GFSK
7206.476000	52.73	73.98	21.25	211.00	165.00	V	Low	GFSK
7320.982000	54.55	73.98	19.43	553.00	330.00	H	Mid	GFSK
7440.188000	50.80	73.98	23.18	148.00	176.00	V	High	GFSK
9921.010000	55.38	73.98	18.60	134.00	150.00	V	High	GFSK

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above.  
All other measurements were found to be at least 6 dB below the limit.

Average Measurements, GMSK-GFSK								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2401.740000	80.04	94.00	13.96	120.00	7.00	V	Low	GFSK
2439.690000	84.09	94.00	9.91	187.00	2.00	V	Mid	GFSK
2479.624000	81.47	94.00	12.53	174.00	8.00	V	High	GFSK
7206.476000	36.25	53.98	17.73	211.00	165.00	V	Low	GFSK
7320.982000	38.07	53.98	15.91	553.00	330.00	H	Mid	GFSK
7440.188000	34.32	53.98	19.66	148.00	176.00	V	High	GFSK
9921.010000	38.90	53.98	15.08	134.00	150.00	V	High	GFSK

Average Level = Peak Level + DCCF, see section 4.3 for more info on DCCF

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the table above.  
All other measurements were found to be at least 6 dB below the limit.



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### 4.3 BAND EDGES

**Test Method:** All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of band-edge measurements:**

**For FCC Part 15.249 Device:**

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in § 15.209, whichever is the lesser attenuation.

**Test procedures:**

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

Comments:

1. All the band edge plots can be found in the Appendix C.
2. If the device falls under FCC Part 15.249 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing compliance with 15.209.
3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209.
4. Tabulated data is listed in section 4.0.



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#### 4.4 CONDUCTED AC MAINS EMISSIONS

**Test Method:** ANSI C63.10-2013, Section(s) 6.2

**Limits for conducted emissions measurements:**

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dB $\mu$ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

**Notes:**

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

**Test Procedures:**

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

**Deviation from the test standard:**

No deviation

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

Test Results:



Figure 6 - Conducted Emissions Plot, Line, TX



Figure 7 - Conducted Emissions Plot, Neutral, TX

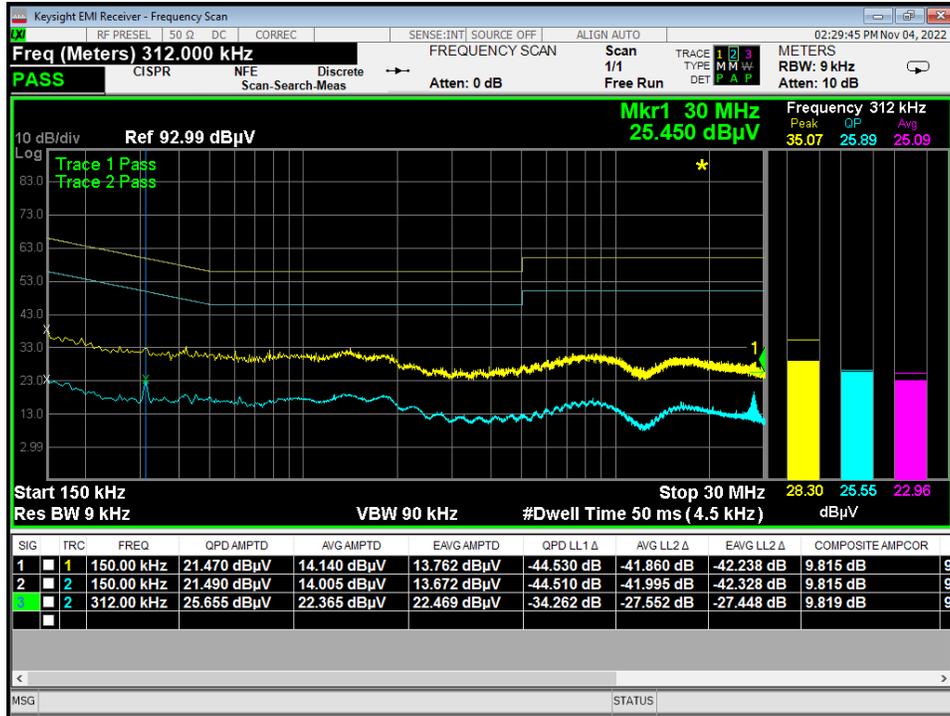


Figure 8 - Conducted Emissions Plot, Line, IDLE



Figure 9 - Conducted Emissions Plot, Neutral, IDLE



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**APPENDIX A: SAMPLE CALCULATION**

**Field Strength Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

- RA = Receiver Amplitude
- AF = Antenna Factor
- CF = Cable Attenuation Factor
- AG = Amplifier Gain
- AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB $\mu$ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB $\mu$ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by the taking the  $20 \cdot \log(T_{on}/100)$  where  $T_{on}$  is the maximum transmission time in any 100ms window.



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**EIRP Calculations**

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

$$EIRP (Watts) = [Field Strength (V/m) \times antenna distance (m)]^2 / 30$$

$$Power (watts) = 10^{[Power (dBm)/10]} / 1000$$

$$Voltage (dB\mu V) = Power (dBm) + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$Field Strength (V/m) = 10^{[Field Strength (dB\mu V/m) / 20]} / 10^6$$

$$Gain = 1 \text{ (numeric gain for isotropic radiator)}$$

Conversion from 3m field strength to EIRP (d=3):

$$EIRP = [FS(V/m) \times d^2]/30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS(dB\mu V/m) - 95.23$$

*10log( 10^9) is the conversion from micro to milli*



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**APPENDIX B – MEASUREMENT UNCERTAINTY**

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

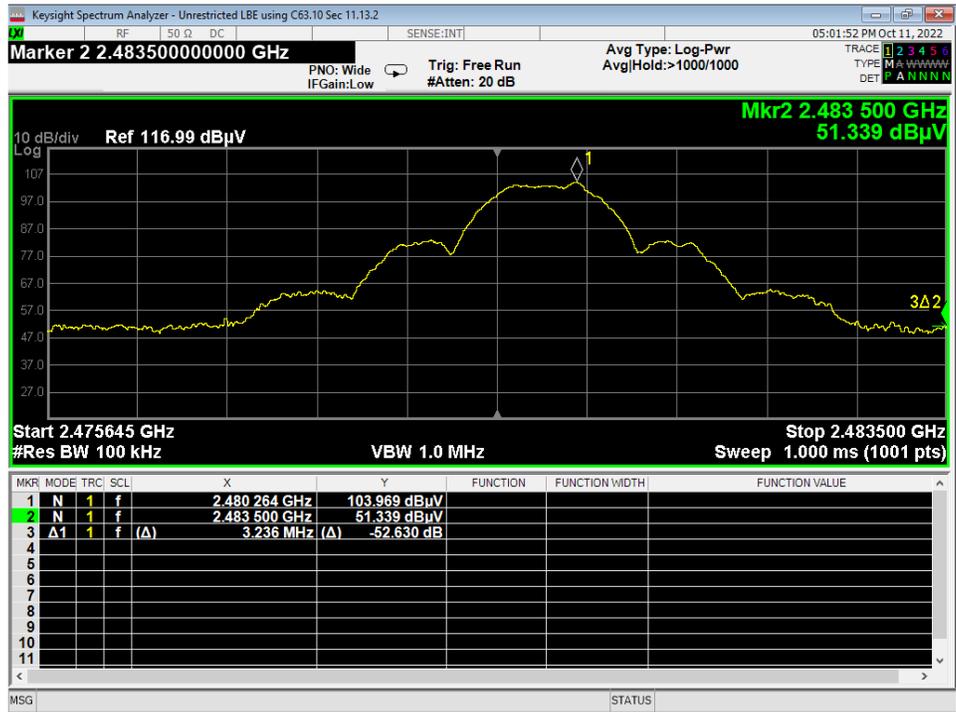
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

Expanded uncertainty values are calculated to a confidence level of 95%.

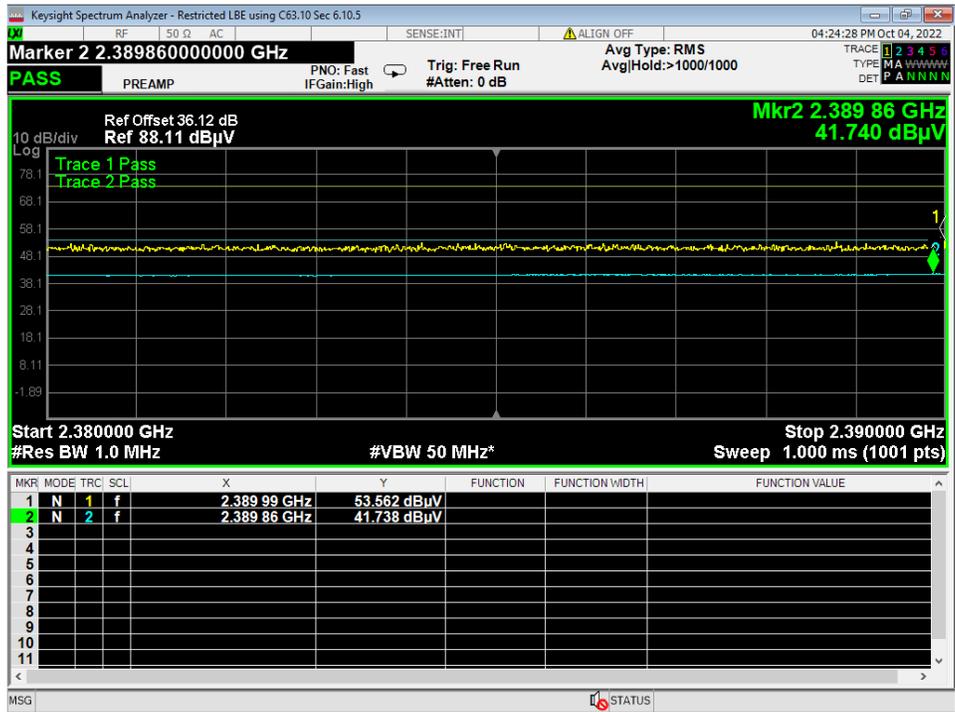
APPENDIX C – GRAPHS AND TABLES



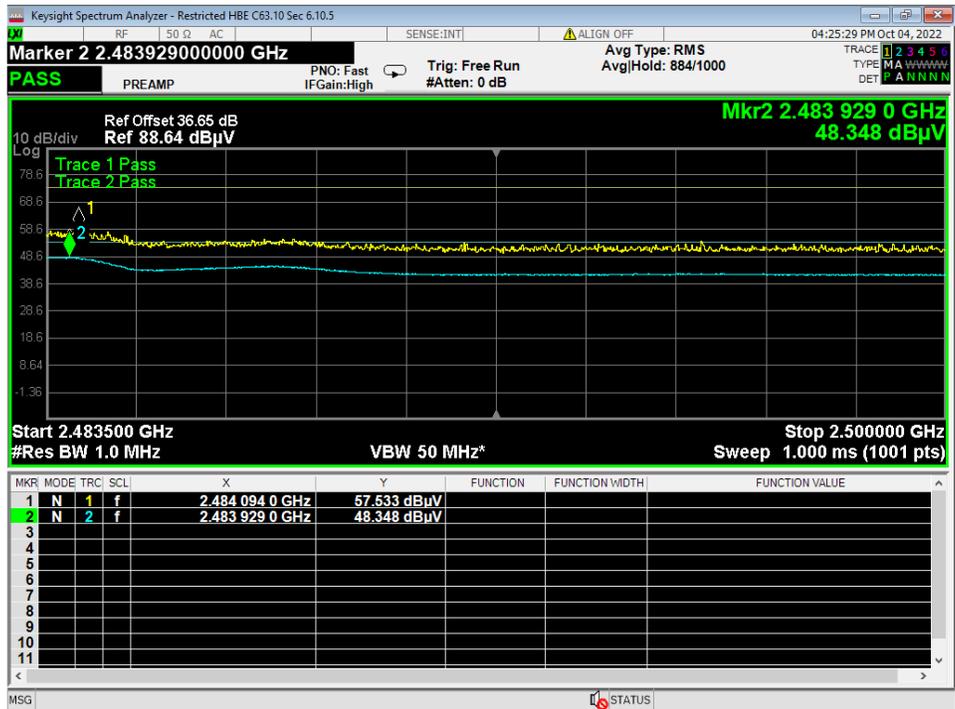
**04 Lower Bandedge, Unrestricted, GFSK, 15.209 limits**  
Disregard trace 2, duty cycle correction was added to peak level



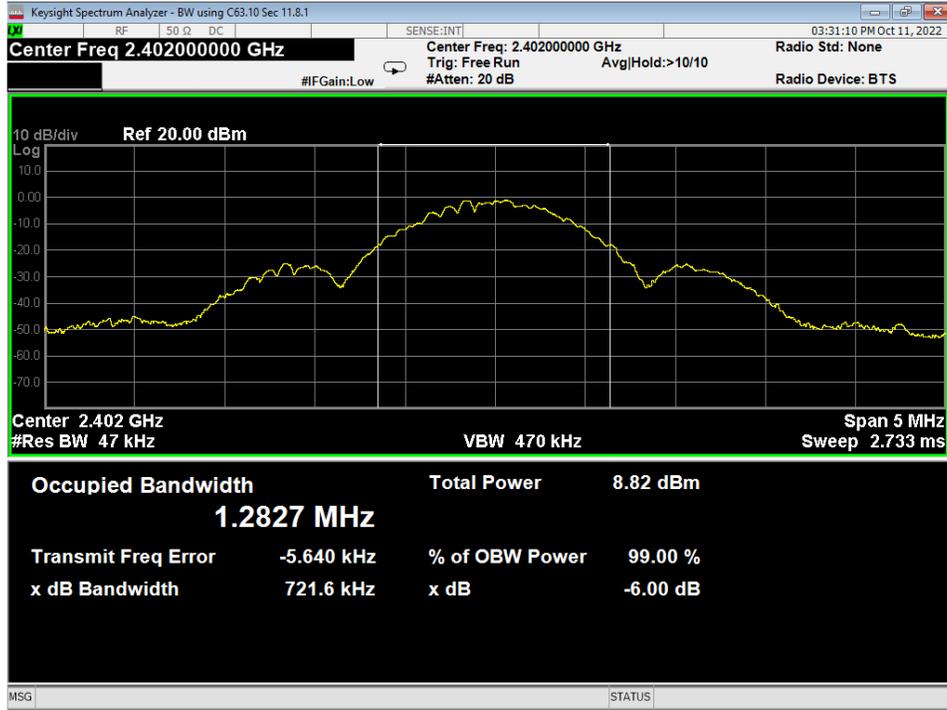
**05 Higher Bandedge, Unrestricted, GFSK**



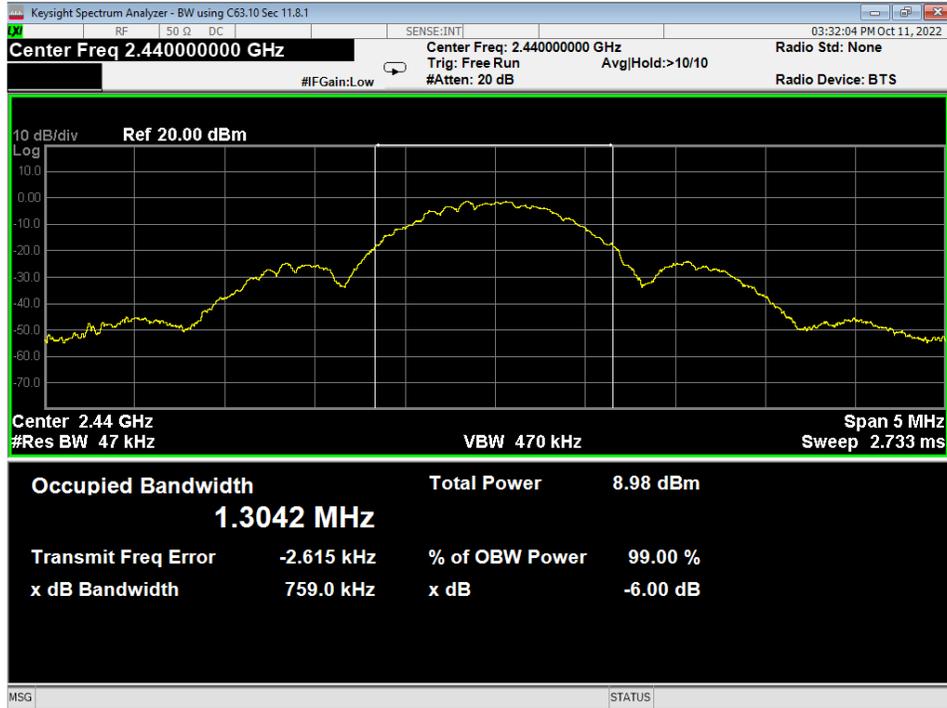
06 Lower Bandedge, Restricted, GFSK



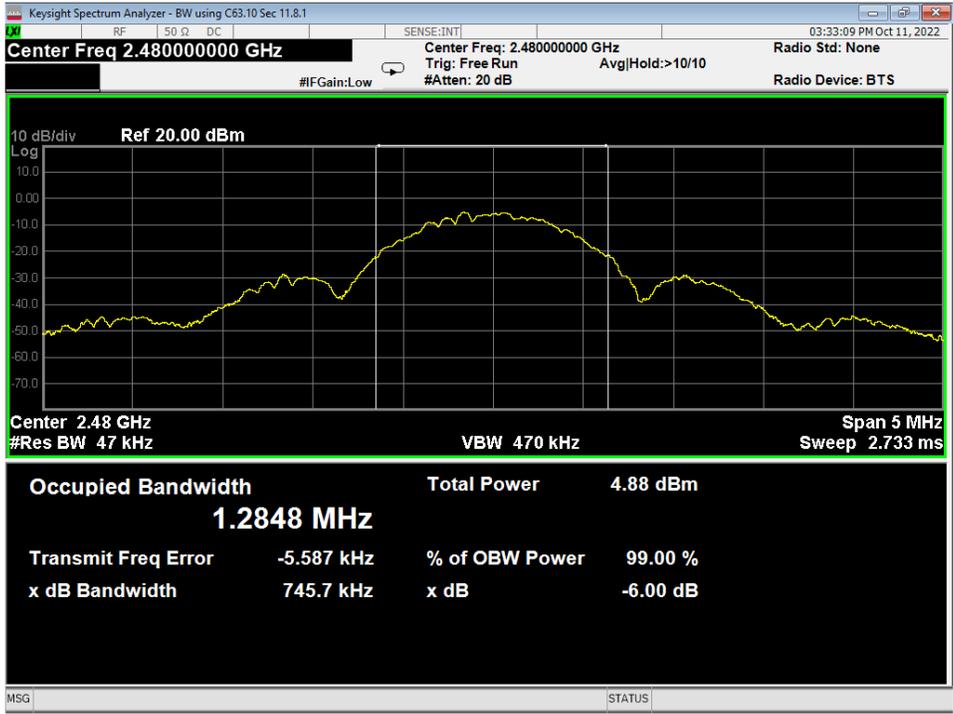
07 Higher Bandedge, Restricted, GFSK



08 Occupied Bandwidth, Low Channel, GFSK



09 Occupied Bandwidth, Mid Channel, GFSK



10 Occupied Bandwidth, High Channel, GFSK



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REPORT END

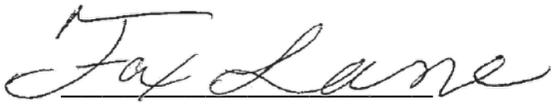
## FCC/ISED DXX Part 15.225 Test Report

**Prepared for:** Garmin International Inc.

**Address:** 1200 E. 151<sup>st</sup> Street  
Olathe, Kansas, 66062, USA

**Product:** A04452

**Test Report No:** R20220901-21-E4A

**Approved By:**  
  
Fox Lane  
EMC Test Engineer

**DATE:** 30 November 2022

**Total Pages:** 21



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	Prepared for:	Garmin International, Inc.		

## Revision Page

Rev. No.	Date	Description
0	18 November 2022	Issued by FLane Reviewed by KVepuri Prepared by FLane, GLarsen
A	30 November 2022	Updated Table 2 to reflect transmitter under test - FL

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	Prepared for:	Garmin International, Inc.		

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	Prepared for:	Garmin International, Inc.		

# 1 Summary of Test Results

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section(s):

## 1.1 Emissions Test Results

The EUT was tested for compliance to:

US CFR Title 47 FCC Part 15.225  
RSS-210 Issue 10

**Table 1 – Emissions Test Results**

Emissions Tests	Test Method and Limits	Result
Radiated Emissions	FCC Part 15.225 (a), (b), (c), (d) RSS-Gen, Issue 5, 6.5, 6.13 RSS-210 Issue 10 B.6	Complies
Bandedge	FCC Part 15.225 (b) (c) RSS-210 Issue 10 B.6	Complies

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	Prepared for:	Garmin International, Inc.		

## 2 EUT Description

### 2.1 Equipment under Test (EUT)

Table 2 – Equipment under Test (EUT)

<b>EUT</b>	A04452
<b>IC</b>	1792A-04452
<b>FCC ID</b>	IPH-04452
<b>EUT Received</b>	3 October 2022
<b>EUT Tested</b>	3 October 2022- 7 November 2022
<b>Serial No.</b>	3426283485 (Radiated Measurements) 3426283465 (Conducted Measurements)
<b>Operating Band</b>	2400 – 2483.5 MHz
<b>Device Type</b>	<input type="checkbox"/> GMSK <input type="checkbox"/> GFSK <input type="checkbox"/> BT BR <input type="checkbox"/> BT EDR 2MB <input type="checkbox"/> BT EDR 3MB <input type="checkbox"/> 802.11x <input checked="" type="checkbox"/> NFC
<b>Power Supply / Voltage</b>	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: AQ27A-59CFA GPN: 362-00118-00 (Representative Power Supply)

### 2.2 Laboratory Description

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)  
4740 Discovery Drive  
Lincoln, NE 68521

A2LA Certificate Number: 1953.01  
FCC Accredited Test Site Designation No: US1060  
Industry Canada Test Site Registration No: 4294A-1  
NCC CAB Identification No: US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of  $28 \pm 4\%$   
Temperature of  $22 \pm 3^\circ\text{C}$

### 2.3 EUT Setup

The EUT was powered by 120 VAC / 60Hz (5 VDC Output) for all tests. Emissions were compared between EUT charging and non-charging; worst case was reported. EUT was paired with an NFC card reader (MN: ACR122U, SN: RR545-026162) for all testing.

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	Prepared for:	Garmin International, Inc.		

### 3 Test Results

#### 3.1 Radiated Emissions, Band Width, Field Strength and Band edge

<b>Test:</b>	FCC Part 15.225 (a), (b), (c), (d)
<b>Test Specifications:</b>	Class A
<b>Test Result:</b>	Complies

##### 3.1.1 Test Description

Radiated emissions measurements were made from 30MHz to 1GHz at a distance of 3m (Radiated Emissions) and 3m (Bandwidth, Field Strength and Band edges) inside a semi-anechoic chamber. The EUT was rotated 360°, the antenna height varied from 1-4 meters and both the vertical and horizontal antenna polarizations examined. For measurements below 30 MHz, the loop antenna was used to measure in all 3 axes. The results were compared against the limits. Measurements were made by first using a spectrum analyzer to acquire the signal spectrum; individual frequencies were then measured using a CISPR 16.1 compliant receiver with the following bandwidth setting:

- 30MHz – 1GHz: 120kHz IF bandwidth, 60kHz steps
- 150kHz – 30MHz: 9kHz RBW, 4.5 kHz steps

Intermodulation products were investigated by measuring spurious emissions with each of the two 2.4 GHz radios running in parallel with the NFC radio. No intermodulation products were found above the labs system sensitivity.

##### 3.1.2 Test Results

No radiated emissions measurements were found in excess of the limits. Test result data can be seen below.

##### 3.1.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility in the 10m semi-anechoic chamber. Laboratory environmental conditions varied slightly throughout the test:

- Relative humidity of  $30 \pm 5\%$
- Temperature of  $23 \pm 2^\circ \text{C}$

##### 3.1.4 Test Setup

See Section 2.3 for further details.

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	Prepared for:	Garmin International, Inc.		

### 3.1.5 Test Equipment Used

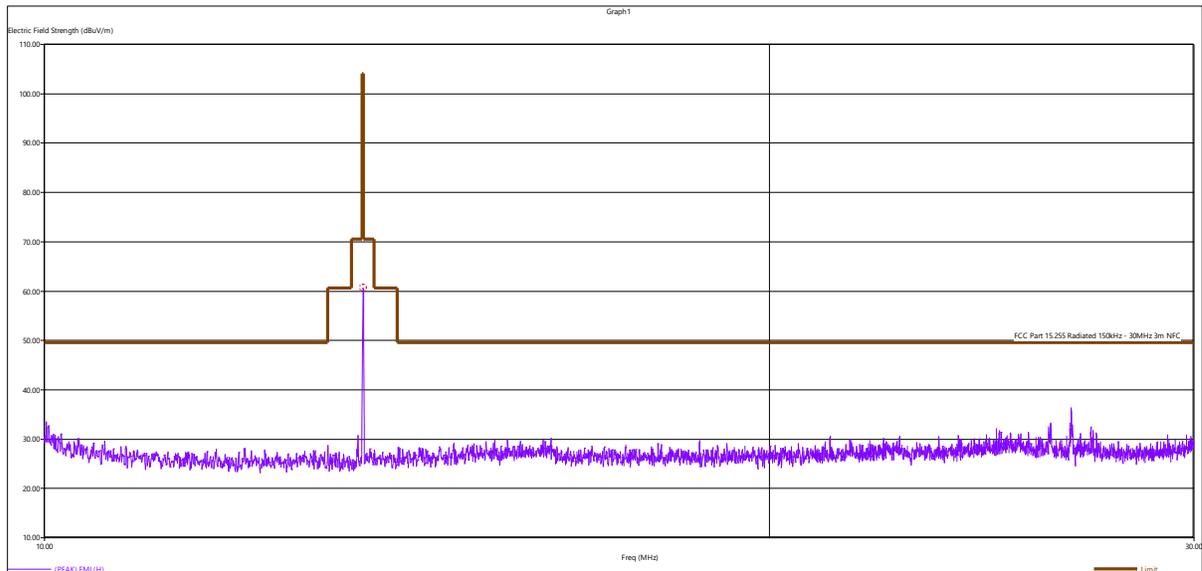
DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
Com-Power Active Loop Antenna	AI-130R	10160084	April 12, 2022	April 12, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preamplifier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	90-195-040	August 22, 2022	August 22, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

\*Internal Characterization

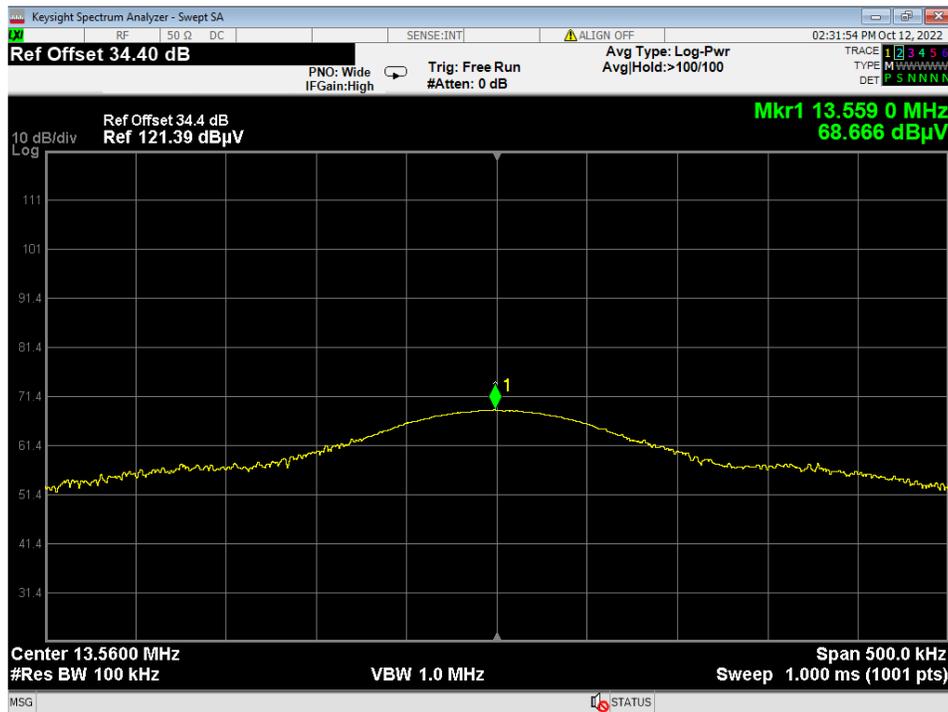
\*\*Two Year Calibration Cycle

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	Prepared for:	Garmin International, Inc.		

### 3.1.6 Test Pictures and/or Figures



**Figure 1 – NFC Radiated Emissions Plot, 10MHz – 30MHz**  
 All emissions found to be at least 6dB below limit line



**Figure 2 – Field Strength, 3m**

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	Prepared for:	Garmin International, Inc.		

NFC Field Strength			
Field Strength (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)*	Margin	Result
68.666	104.00	35.334	PASS

\*Limit extrapolated to 3m test distance.

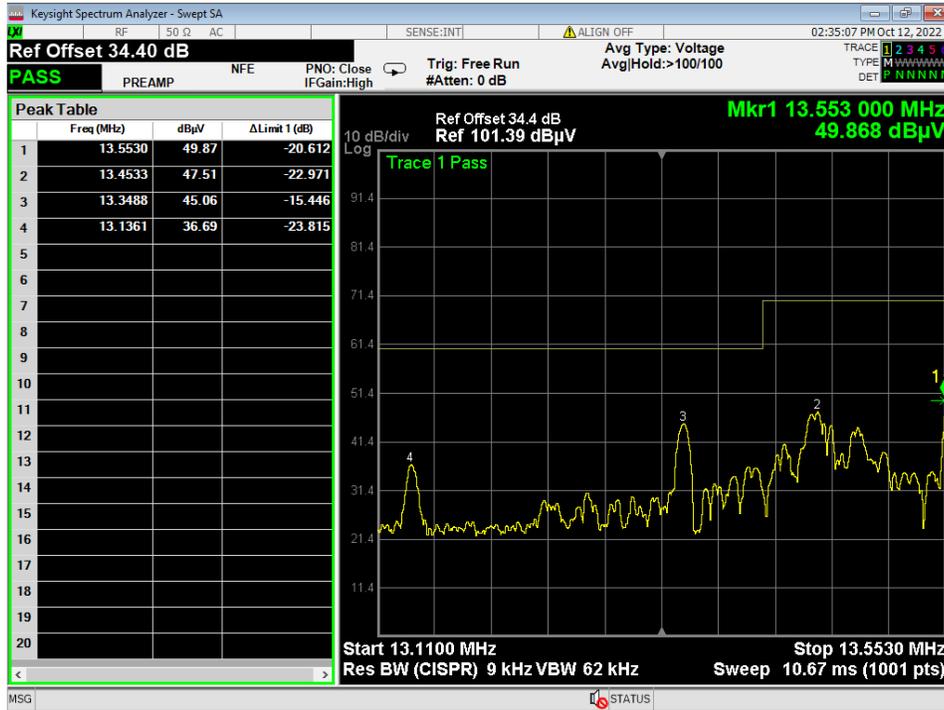


Figure 3 – Lower Band Edge

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	Prepared for:	Garmin International, Inc.		

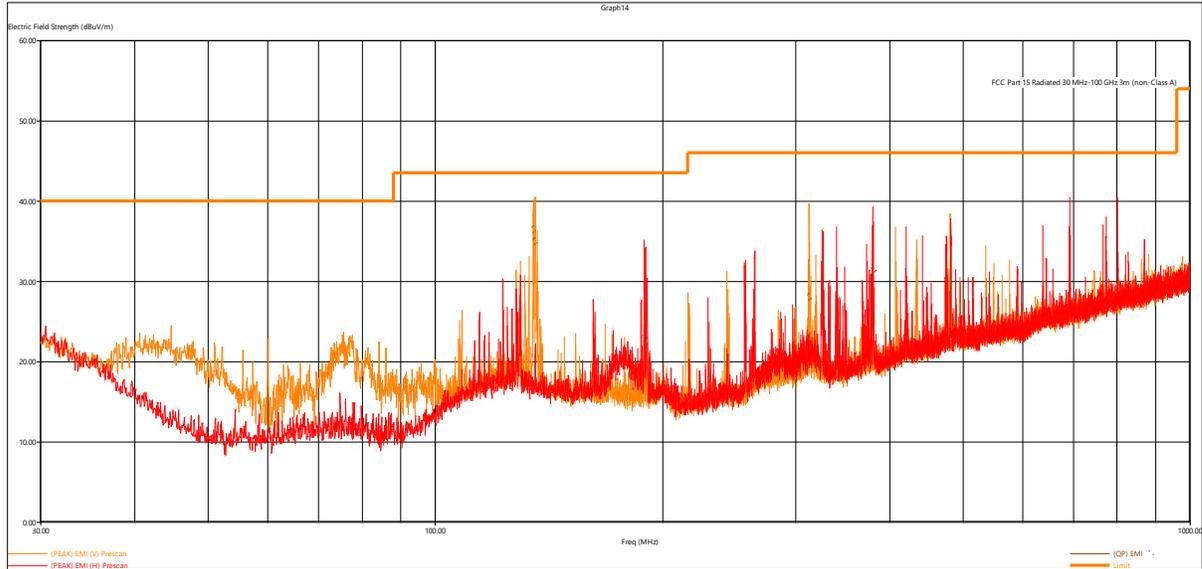


Figure 4 – Upper Bandedge

Band Edge Measurements				
Band edge /Measurement Frequency (MHz)	Corrected band level dBμV/m @ 3m	Limit* dBμV	Margin	Result
13.3488	45.06	60.51	15.45	PASS
13.7734	44.63	60.51	15.88	PASS

\*Limit extrapolated to 3m test distance

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot above. All other emissions found to be at least 6dB below the limit line.



**Figure 5 – NFC Radiated Emissions Plot, 30MHz – 1GHz**  
 All emissions found to be at least 6dB below limit line

Quasi-Peak Measurements, 30MHz – 1GHz						
Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.	
189.068880	22.95	43.52	20.57	118.00	331.00	H
379.793520	31.33	46.02	14.69	233.00	85.00	H
692.496720	26.81	46.02	19.21	123.00	115.00	H
801.222960	29.65	46.02	16.37	209.00	104.00	H
134.772240	36.39	43.52	7.13	115.00	278.00	V
135.624000	34.90	43.52	8.62	209.00	234.00	V
312.644400	27.94	46.02	18.08	127.00	166.00	V
480.975360	23.63	46.02	22.39	214.00	162.00	V
189.068880	22.95	43.52	20.57	118.00	331.00	H

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above. All other emissions found to be at least 6dB below the limit line. System Noise floor was at least 6 dB below the limit line throughout the test range.

	Report Number:	R20220901-21-E4A	Rev	A
	Prepared for:	Garmin International, Inc.		

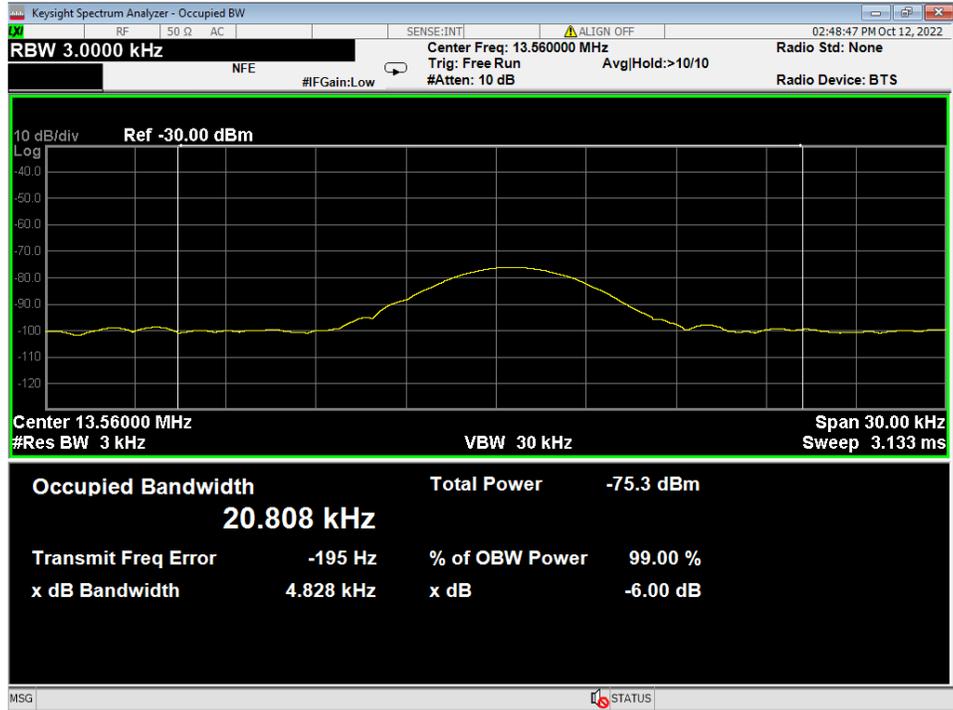


Figure 6 – NFC Occupied Bandwidth

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### 3.2 Frequency Error

<b>Test:</b>	FCC Part 15.225 (e)
<b>Test Result:</b>	Complies

#### 3.2.1 Test Description

Frequency error was determined using the built-in frequency error function of the spectrum analyzer. The analyzer finds the occupied bandwidth, calculates the center of the given band then returns the deviation with respect to the given transmit frequency. The temperature was varied from -20°C to 55°C. The voltage was not variable but the battery was let to drain, voltage of drained battery was reported.  
Limit: 100 PPM

#### 3.2.2 Test Results

No results were found to be in excess of the limits. A table of the results can be seen below.

#### 3.2.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility.  
Laboratory environmental conditions varied slightly throughout the test:  
Relative humidity of 30 ± 5%  
Temperature of 23 ± 2° C

#### 3.2.4 Test Setup

Device was tested at 100% battery and 1% battery for worst case voltage for frequency error.  
See Section 2.3 for further details.

#### 3.2.5 Test Equipment Used

See section 2.4 for the equipment list.

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### 3.2.6 Test results

A04453	
Temperature (°C)	Channel (Hz)
	13.56000 Nom.
-20°C	680
-10°C	626
0°C	600
10°C	550
20°C	525
30°C	545
40°C	452
50°C	400

A04453		Nominal Battery Voltage: 3.87V
Voltage (V)	Temperature	Frequency Error (Hz)
3.78*	20°C	524
3.99	20°C	528
4.10	20°C	528
4.43*	20°C	528

\*Tested voltage was the lowest/highest we could get battery powered EUT to achieve

Limit: 100 PPM = 0.01% = 0.01 x 13.56 kHz = 1356 Hz  
 Values shown in Hz.  
 Uncertainty = ±200 Hz

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### 3.3 Conducted AC Mains Emissions

**Test Method:** ANSI C63.10-2013, Section(s) 6.2

**Limits for conducted emissions measurements:**

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dB $\mu$ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

**Notes:**

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

**Test Procedures:**

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

**Deviation from the test standard:**

No deviation

**EUT operating conditions:**

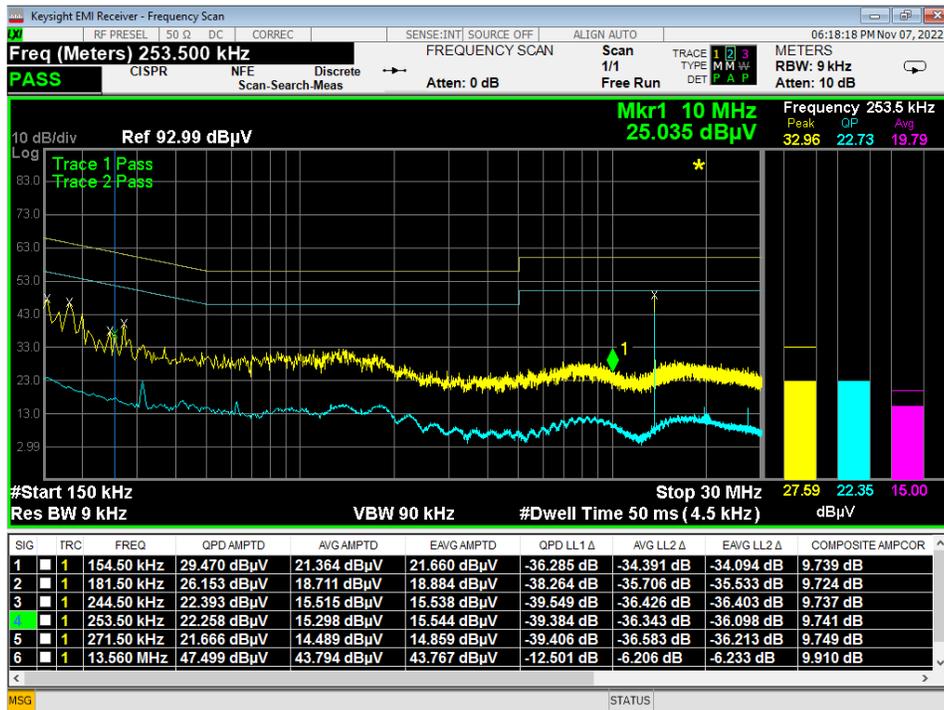
Details can be found in section 2.1 of this report.

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**Test Results:**



**Figure 7 – Conducted Emissions Plot, Line, NFC**



**Figure 8 – Conducted Emissions Plot, Neutral, NFC**

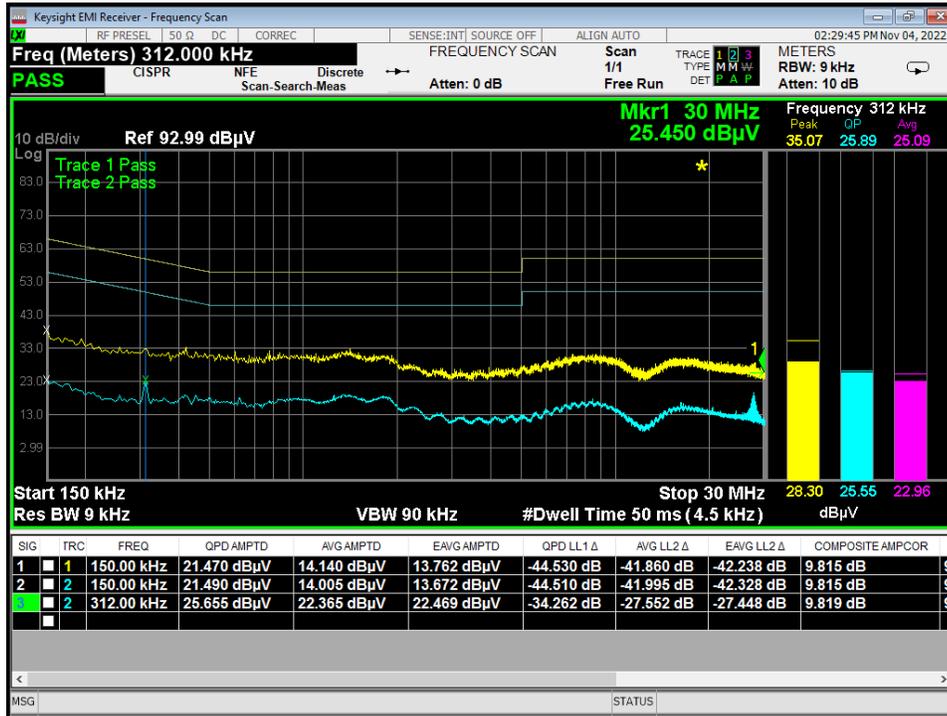


Figure 9 – Conducted Emissions Plot, Line, Idle

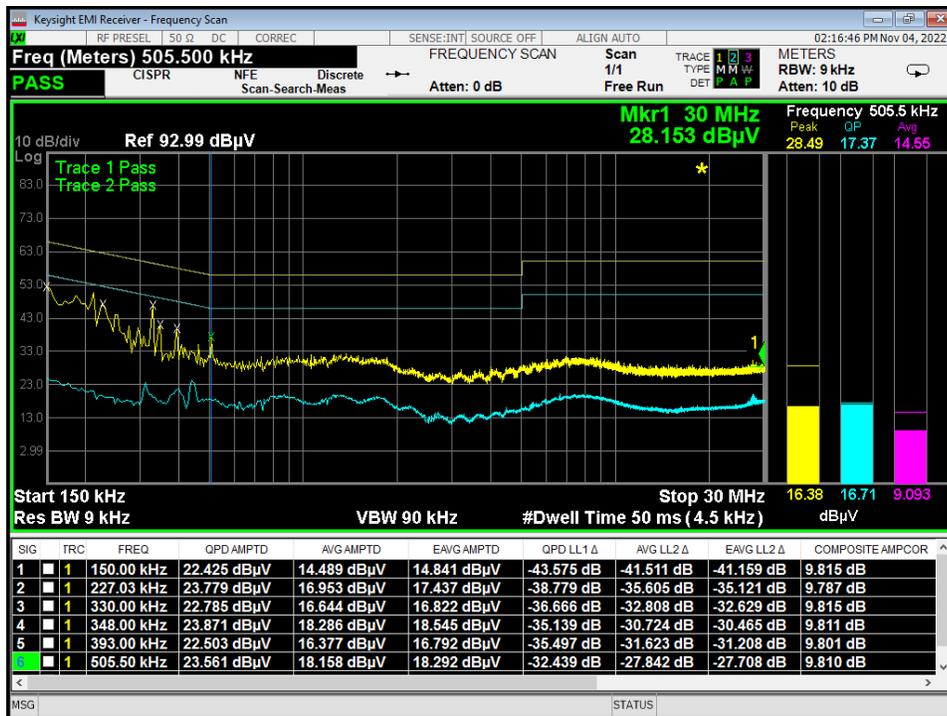


Figure 10 – Conducted Emissions Plot, Neutral, Idle

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## APPENDIX A: SAMPLE CALCULATION

### Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB $\mu$ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB $\mu$ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by the taking the  $20 \cdot \log(T_{on}/100)$  where  $T_{on}$  is the maximum transmission time in any 100ms window.

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### EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

$$EIRP \text{ (Watts)} = [\text{Field Strength (V/m)} \times \text{antenna distance (m)}]^2 / 30$$

$$\text{Power (watts)} = 10^{[\text{Power (dBm)}/10]} / 1000$$

$$\text{Voltage (dB}\mu\text{V)} = \text{Power (dBm)} + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$\text{Field Strength (V/m)} = 10^{[\text{Field Strength (dB}\mu\text{V/m)} / 20]} / 10^6$$

$$\text{Gain} = 1 \text{ (numeric gain for isotropic radiator)}$$

Conversion from 3m field strength to EIRP (d=3):

$$EIRP = [\text{FS (V/m)} \times d^2] / 30 = \text{FS} [0.3] \quad \text{for } d = 3$$

$$EIRP(\text{dBm}) = \text{FS}(\text{dB}\mu\text{V/m}) - 10(\log 10^9) + 10\log[0.3] = \text{FS}(\text{dB}\mu\text{V/m}) - 95.23$$

*10log( 10^9) is the conversion from micro to milli*

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**APPENDIX B – MEASUREMENT UNCERTAINTY**

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

<b>Test</b>	<b>Frequency Range</b>	<b>Uncertainty Value (dB)</b>
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

Expanded uncertainty values are calculated to a confidence level of 95%.

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**REPORT END**

# RF Exposure Lab

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TEL (760) 471-2100 • FAX (760) 471-2121

<http://www.rfexposurelab.com>

## CERTIFICATE OF COMPLIANCE SAR EVALUATION

Garmin International, Inc.  
1200 E. 151<sup>st</sup> Street  
Olathe, KS 66062

Dates of Test: November 14-16, 2022  
Test Report Number: SAR.20221106

Revision A

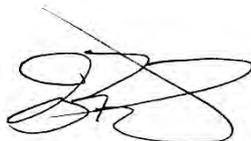
Lab Designation Number: US1195(FCC) & US0194(ISED)

FCC ID:	IPH-04452
IC Certificate:	1792A-04452
Model(s):	A04452
Test Sample:	Engineering Unit Same as Production
Serial No.:	426283464
Equipment Type:	Digital Transmission System Transceiver
Classification:	Portable Transmitter Next to Extremity
TX Frequency Range:	2402 – 2480 MHz; 2412 – 2462 MHz
Frequency Tolerance:	± 2.5 ppm
Maximum RF Output:	2450 MHz (b) – 18.0 dBm, 2450 MHz (g) – 15.0 dBm, 2450 MHz (n) – 15.0 dBm, 2450 MHz (BT) – 10.5 dBm, 2450 MHz (ANT) – 2.0 dBm, 13.56 MHz – <0 dBm Conducted
Signal Modulation:	GFSK, DSSS, OFDM
Antenna Type:	Internal Antenna
Application Type:	Certification
FCC Rule Parts:	Part 2, 15C
KDB Test Methodology:	KDB 447498 D01 v06, KDB 865664 D01 v01r04, KDB 865664 D02 v01r02
Industry Canada:	RSS-102 Issue 5, Safety Code 6
Max. Stand Alone SAR Value:	0.96 W/kg Reported
Separation Distance:	0 mm

This wireless mobile and/or portable device has been shown to be compliant for localized specific absorption rate (SAR) for uncontrolled environment/general exposure limits specified in ANSI/IEEE Std. C95.1-1992 and had been tested in accordance with the measurement procedures specified in IEEE 1528-2013 and IEC 62209-1528:2020 (See test report).

I attest to the accuracy of the data. All measurements were performed by myself or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

RF Exposure Lab, LLC certifies that no party to this application has been denied FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. 853(a).



Jay M. Moulton  
Vice President



Testing Cert. # 2387.01

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Comment/Revision	Date
Original Release	November 17, 2022
Revision A – Correct model number to A04452 and IDs to -04452	November 23, 2022

**Note: The latest version supersedes all previous versions listed in the above table. The latest version shall be used.**

## 1. Introduction

This measurement report shows compliance of the Garmin International, Inc. Model A04452 FCC ID: IPH-04452 with FCC Part 2, 1093, ET Docket 93-62 Rules for mobile and portable devices and IC Certificate: 1792A-04452 with RSS102 Issue 5 & Safety Code 6. The FCC/ISED have adopted the guidelines for evaluating the environmental effects of radio frequency radiation to protect the public and workers from the potential hazards of RF emissions due to FCC/ISED regulated portable devices. [1], [6]

The test results recorded herein are based on a single type test of Garmin International, Inc. Model A04452 and therefore apply only to the tested sample.

The test procedures and limits, as described in ANSI C95.1 – 1999 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz [2], ANSI C95.3 – 2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields [3], IEEE Std.1528 – 2003 Recommended Practice [4], and Industry Canada Safety Code 6 Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz were employed.

The following table indicates all the wireless technologies operating in the A04452 Digital Transmission System Transceiver. The table also shows the tolerance for the power level for each mode.

Band	Technology	Rel.	Class	3GPP Nominal Power dBm	Setpoint Nominal Power dBm	Tolerance dBm	Lower Tolerance dBm	Upper Tolerance dBm
WiFi – 2.4 GHz	802.11b	N/A	N/A	N/A	N/A	N/A	N/A	18.0
WiFi – 2.4 GHz	802.11g	N/A	N/A	N/A	N/A	N/A	N/A	15.0
WiFi – 2.4 GHz	802.11n	N/A	N/A	N/A	N/A	N/A	N/A	15.0
Bluetooth	BT Classic	N/A	N/A	N/A	N/A	N/A	N/A	10.5
Bluetooth	BT BR	N/A	N/A	N/A	N/A	N/A	N/A	10.5
Bluetooth	BLE	N/A	N/A	N/A	N/A	N/A	N/A	2.0
Ant	Ant	N/A	N/A	N/A	N/A	N/A	N/A	2.0
13.56 MHz	13.56 MHz	N/A	N/A	N/A	N/A	N/A	N/A	< 0.0

**SAR Definition [5]**

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy ( $dW$ ) absorbed by (dissipated in) an incremental mass ( $dm$ ) contained in a volume element ( $dV$ ) of a given density ( $\rho$ ).

$$SAR = \frac{d}{dt} \left( \frac{dW}{dm} \right) = \frac{d}{dt} \left( \frac{dW}{\rho dV} \right)$$

SAR is expressed in units of watts per kilogram (W/kg). SAR can be related to the electric field at a point by

$$SAR = \frac{\sigma |E|^2}{\rho}$$

where:

$\sigma$  = conductivity of the tissue (S/m)

$\rho$  = mass density of the tissue (kg/m<sup>3</sup>)

$E$  = rms electric field strength (V/m)

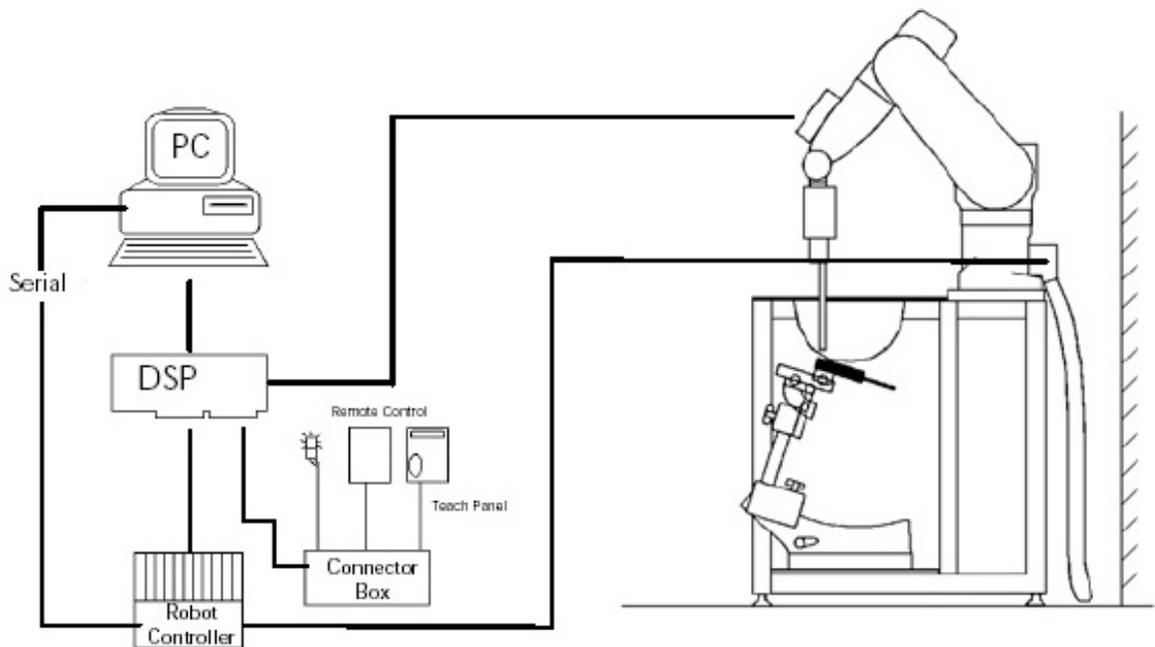
## 2. SAR Measurement Setup

### Robotic System

These measurements are performed using the DASY52 automated dosimetric assessment system. The DASY52 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Intel Core2 computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. 2.1).

### System Hardware

A cell controller system contains the power supply, robot controller teach pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the HP Intel Core2 computer with Windows XP system and SAR Measurement Software DASY52, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.



**Figure 2.1 SAR Measurement System Setup**

## System Electronics

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail in.

## Probe Measurement System

The SAR measurements were conducted with the dosimetric probe EX3DV4, designed in the classical triangular configuration (see Fig. 2.2) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multi fiber line ending at the front of the probe tip. (see Fig. 2.3) It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY52 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped at reaching the maximum.



**DAE System**

**Probe Specifications**

**Calibration:** In air from 10 MHz to 6.0 GHz  
In brain and muscle simulating tissue at Frequencies of 450 MHz, 835 MHz, 1750 MHz, 1900 MHz, 2450 MHz, 2600 MHz, 3500 MHz, 5200 MHz, 5300 MHz, 5600 MHz, 5800 MHz

**Frequency:** 10 MHz to 6 GHz

**Linearity:**  $\pm 0.2$ dB (30 MHz to 6 GHz)

**Dynamic:** 10 mW/kg to 100 W/kg

**Range:** Linearity:  $\pm 0.2$ dB

**Dimensions:** Overall length: 330 mm

**Tip length:** 20 mm

**Body diameter:** 12 mm

**Tip diameter:** 2.5 mm

**Distance from probe tip to sensor center:** 1 mm

**Application:** SAR Dosimetry Testing  
Compliance tests of wireless device

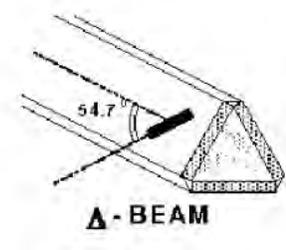


Figure 2.2 Triangular Probe Configurations



Figure 2.3 Probe Thick-Film Technique

**Probe Calibration Process**

**Dosimetric Assessment Procedure**

Each probe is calibrated according to a dosimetric assessment procedure described in with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure described in and found to be better than +/-0.25dB. The sensitivity parameters (Norm X, Norm Y, Norm Z), the diode compression parameter (DCP) and the conversion factor (Conv F) of the probe is tested.

**Free Space Assessment**

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz, and in a waveguide above 1GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/cm<sup>2</sup>.

**Temperature Assessment \***

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium, correlates to temperature rise in a dielectric medium. For temperature correlation calibration a RF transparent thermistor based temperature probe is used in conjunction with the E-field probe

$$SAR = C \frac{\Delta T}{\Delta t}$$

$$SAR = \frac{|E|^2 \cdot \sigma}{\rho}$$

where:

where:

$\Delta t$  = exposure time (30 seconds),

$\sigma$  = simulated tissue conductivity,

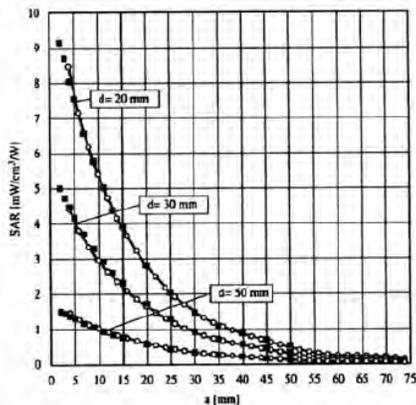
C = heat capacity of tissue (brain or muscle),

$\rho$  = Tissue density (1.25 g/cm<sup>3</sup> for brain tissue)

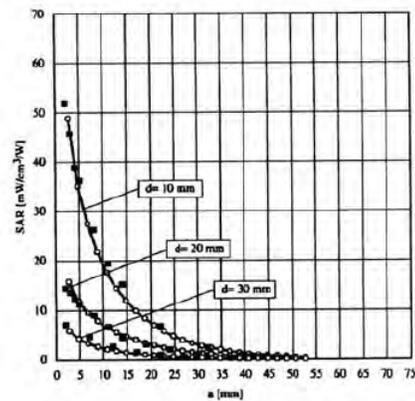
$\Delta T$  = temperature increase due to RF exposure.

SAR is proportional to  $\Delta T / \Delta t$ , the initial rate of tissue heating, before thermal diffusion takes place.

Now it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;



**Figure 2.4 E-Field and Temperature Measurements at 900MHz**



**Figure 2.5 E-Field and Temperature Measurements at 1800MHz**

## Data Extrapolation

The DASY52 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given like below;

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with

- $V_i$  = compensated signal of channel i (i=x,y,z)
- $U_i$  = input signal of channel i (i=x,y,z)
- cf = crest factor of exciting field (DASY parameter)
- dcp<sub>i</sub> = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

with

- $V_i$  = compensated signal of channel i (i = x,y,z)
- Norm<sub>i</sub> = sensor sensitivity of channel i (i = x,y,z)  
μV/(V/m)<sup>2</sup> for E-field probes
- ConvF = sensitivity of enhancement in solution
- $E_i$  = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermetian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with

- SAR = local specific absorption rate in W/g
- $E_{tot}$  = total field strength in V/m
- σ = conductivity in [mho/m] or [Siemens/m]
- ρ = equivalent tissue density in g/cm<sup>3</sup>

The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{pwc} = \frac{E_{tot}^2}{3770}$$

with

- $P_{pwc}$  = equivalent power density of a plane wave in W/cm<sup>2</sup>
- $E_{tot}$  = total electric field strength in V/m

**Scanning procedure**

- The DASY installation includes predefined files with recommended procedures for measurements and system check. They are read-only document files and destined as fully defined but unmeasured masks. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.
- The „reference“ and „drift“ measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the DUT's output power and should vary max. +/- 5 %.
- The highest integrated SAR value is the main concern in compliance test applications. These values can mostly be found at the inner surface of the phantom and cannot be measured directly due to the sensor offset in the probe. To extrapolate the surface values, the measurement distances to the surface must be known accurately. A distance error of 0.5mm could produce SAR errors of 6% at 1800 MHz. Using predefined locations for measurements is not accurate enough. Any shift of the phantom (e.g., slight deformations after filling it with liquid) would produce high uncertainties. For an automatic and accurate detection of the phantom surface, the DASY5 system uses the mechanical surface detection. The detection is always at touch, but the probe will move backward from the surface the indicated distance before starting the measurement.
- The „area scan“ measures the SAR above the DUT or verification dipole on a parallel plane to the surface. It is used to locate the approximate location of the peak SAR with 2D spline interpolation. The robot performs a stepped movement along one grid axis while the local electrical field strength is measured by the probe. The probe is touching the surface of the SAM during acquisition of measurement values. The scan uses different grid spacings for different frequency measurements. Standard grid spacing for head measurements in frequency ranges ≤ 2GHz is 15 mm in x - and y- dimension. For higher frequencies a finer resolution is needed, thus for the grid spacing is reduced according the following table:

<b>Area scan grid spacing for different frequency ranges</b>	
Frequency range	Grid spacing
≤ 2 GHz	≤ 15 mm
2 – 4 GHz	≤ 12 mm
4 – 6 GHz	≤ 10 mm

Grid spacing and orientation have no influence on the SAR result. For special applications where the standard scan method does not find the peak SAR within the grid, e.g. mobile phones with flip cover, the grid can be adapted in orientation. Results of this coarse scan are shown in annex B.

- A „zoom scan“ measures the field in a volume around the 2D peak SAR value acquired in the previous „coarse“ scan. It uses a fine meshed grid where the robot moves the probe in steps along all the 3 axis (x,y and z-axis) starting at the bottom of the Phantom. The grid spacing for the cube measurement is varied according to the measured frequency range, the dimensions are given in the following table:

<b>Zoom scan grid spacing and volume for different frequency ranges</b>			
Frequency range	Grid spacing for x, y axis	Grid spacing for z axis	Minimum zoom scan volume
≤ 2 GHz	≤ 8 mm	≤ 5 mm	≥ 30 mm
2 – 3 GHz	≤ 5 mm	≤ 5 mm	≥ 28 mm
3 – 4 GHz	≤ 5 mm	≤ 4 mm	≥ 28 mm
4 – 5 GHz	≤ 4 mm	≤ 3 mm	≥ 25 mm
5 – 6 GHz	≤ 4 mm	≤ 2 mm	≥ 22 mm

DASY is also able to perform repeated zoom scans if more than 1 peak is found during area scan. In this document, the evaluated peak 1g and 10g averaged SAR values are shown in the 2D-graphics in annex B. Test results relevant for the specified standard (see section 3) are shown in table form in section 7.

## Spatial Peak SAR Evaluation

The spatial peak SAR - value for 1 and 10 g is evaluated after the Cube measurements have been done. The basis of the evaluation are the SAR values measured at the points of the fine cube grid consisting of all points in the three directions x, y and z. The algorithm that finds the maximal averaged volume is separated into three different stages.

- The data between the dipole center of the probe and the surface of the phantom are extrapolated. This data cannot be measured since the center of the dipole is 1 to 2.7 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is about 1 mm (see probe calibration sheet). The extrapolated data from a cube measurement can be visualized by selecting 'Graph Evaluated'.
- The maximum interpolated value is searched with a straight-forward algorithm. Around this maximum the SAR - values averaged over the spatial volumes (1g or 10 g) are computed using the 3d-spline interpolation algorithm. If the volume cannot be evaluated (i.e., if a part of the grid was cut off by the boundary of the measurement area) the evaluation will be started on the corners of the bottom plane of the cube.
- All neighbouring volumes are evaluated until no neighbouring volume with a higher average value is found.

## Extrapolation

The extrapolation is based on a least square algorithm [W. Gander, Computermathematik, p.168-180]. Through the points in the first 3 cm along the z-axis, polynomials of order four are calculated. These polynomials are then used to evaluate the points between the surface and the probe tip. The points, calculated from the surface, have a distance of 1 mm from each other.

## Interpolation

The interpolation of the points is done with a 3d-Spline. The 3d-Spline is composed of three one-dimensional splines with the "Not a knot"-condition [W. Gander, Computermathematik, p.141-150] (x, y and z -direction) [Numerical Recipes in C, Second Edition, p.123ff ].

## Volume Averaging

At First the size of the cube is calculated. Then the volume is integrated with the trapezoidal algorithm. 8000 points (20x20x20) are interpolated to calculate the average.

## Advanced Extrapolation

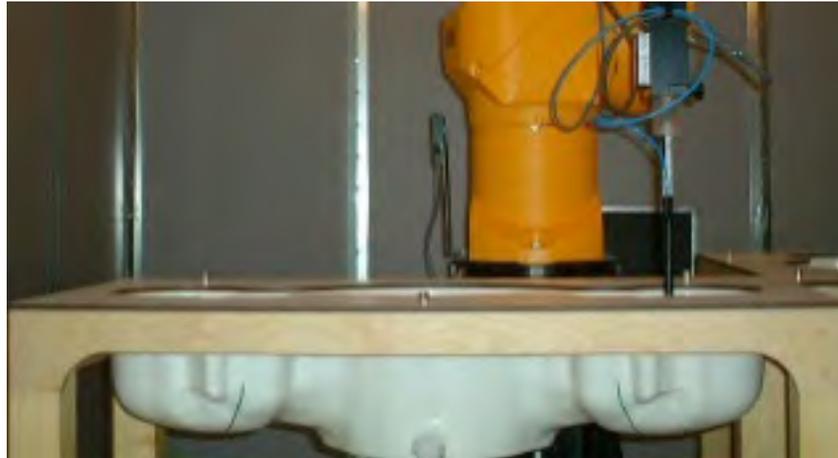
DASY uses the advanced extrapolation option which is able to compensate boundary effects on E-field probes.

**SAM PHANTOM**

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. 2.6)

**Phantom Specification**

**Phantom:** SAM Twin Phantom (V4.0)  
**Shell Material:** Vivac Composite  
**Thickness:**  $2.0 \pm 0.2$  mm



**Figure 2.6 SAM Twin Phantom**

**Device Holder for Transmitters**

In combination with the SAM Twin Phantom V4.0 the Mounting Device (see Fig. 2.7), enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation point is the ear opening. The devices can be easily, accurately, and repeatedly be positioned according to the FCC, CENELEC, IEC and IEEE specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).



**Figure 2.7 Mounting Device**

Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

### **3. Probe and Dipole Calibration**

**See Appendix D and E.**

## 4. Phantom & Simulating Tissue Specifications

### Head & Body Simulating Mixture Characterization

The head and body mixtures consist of the material based on the table listed below. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. Body tissue parameters that have not been specified in IEEE1528-2013 are derived from the issue dielectric parameters computed from the 4-Cole-Cole equations.

**Table 4.1 Typical Composition of Ingredients for Tissue**

Ingredients		Simulating Tissue
		2450 MHz Head
Mixing Percentage		
Water		Proprietary Purchased From Speag
Sugar		
Salt		
HEC		
Bactericide		
DGBE		
Dielectric Constant	Target	39.20
Conductivity (S/m)	Target	1.80

## 5. ANSI/IEEE C95.1 – 1999 RF Exposure Limits [2]

### Uncontrolled Environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

### Controlled Environment

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

**Table 5.1 Human Exposure Limits**

	UNCONTROLLED ENVIRONMENT General Population (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT Professional Population (W/kg) or (mW/g)
SPATIAL PEAK SAR <sup>1</sup> Brain	1.60	8.00
SPATIAL AVERAGE SAR <sup>2</sup> Whole Body	0.08	0.40
SPATIAL PEAK SAR <sup>3</sup> Hands, Feet, Ankles, Wrists	4.00	20.00

<sup>1</sup> The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

<sup>2</sup> The Spatial Average value of the SAR averaged over the whole body.

<sup>3</sup> The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

## 6. Measurement Uncertainty

Measurement uncertainty table is not required per KDB 865664 D01 v01 section 2.8.2 page 12. SAR measurement uncertainty analysis is required in the SAR report only when the highest measured SAR in a frequency band is  $\geq 1.5$  W/kg for 1-g SAR. The equivalent ratio (1.5/1.6) should be applied to extremity and occupational exposure conditions. The highest reported value is less than 1.5 W/kg. Therefore, the measurement uncertainty table is not required.

## 7. System Validation

### Tissue Verification

**Table 7.1 Measured Tissue Parameters**

		2450 MHz Head	
Date(s)		Nov. 14, 2022	
Liquid Temperature (°C)	20.0	Target	Measured
Dielectric Constant: $\epsilon$		39.20	38.67
Conductivity: $\sigma$		1.80	1.82

See Appendix A for data printout.

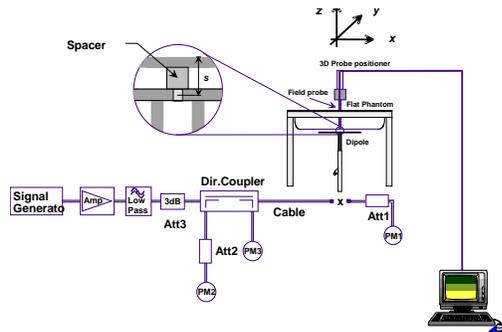
### Test System Verification

Prior to assessment, the system is verified to the  $\pm 10\%$  of the specifications at the test frequency by using the system kit. Power is extrapolated to 1 watt. (Graphic Plots Attached)

**Table 7.2 System Dipole Validation Target & Measured**

	Test Frequency	Targeted SAR <sub>10g</sub> (W/kg)	Measure SAR <sub>10g</sub> (W/kg)	Tissue Used for Verification	Deviation (%)	Plot Number
14-Nov-2022	2450 MHz	25.00	25.10	Head	+ 0.40	1

See Appendix A for data plots.



**Figure 7.1 Dipole Validation Test Setup**

## 8. SAR Test Data Summary

### See Measurement Result Data Pages

See Appendix B for SAR Test Data Plots.  
See Appendix C for SAR Test Setup Photos.

### Procedures Used To Establish Test Signal

The device was placed into simulated transmit mode using the manufacturer's test codes. Such test signals offer a consistent means for testing SAR and are recommended for evaluating SAR. When test modes are not available or inappropriate for testing a device, the actual transmission is activated through a base station simulator or similar equipment. See data pages for actual procedure used in measurement.

### Device Test Condition

In order to verify that the device was tested at full power, conducted output power measurements were performed before and after each SAR measurement to confirm the output power unless otherwise noted. If a conducted power deviation of more than 5% occurred, the test was repeated. The power drift of each test is measured at the start of the test and again at the end of the test. The drift percentage is calculated by the formula  $((\text{end}/\text{start})-1)*100$  and rounded to three decimal places. The drift percentage is calculated into the resultant SAR value on the data sheet for each test.

The EUT was tested on the back side of the device in contact with the ELI Flat phantom for measurements. All measurements were conducted with the side of the device in direct contact with the phantom. All further test reductions are shown on page 22. The device does not allow for simultaneous Tx with the radios. See the photo in Appendix C for a pictorial of the setups.

The strap has been removed for the testing as it is made of plastic. The plastic will not have any effect on the SAR value.

The BLE and ANT transmitters are excluded from SAR testing. The both antennas has a minimum separation distance of 5 mm. Both transmitters are in the same band and the maximum power for BLE is 2.0 dBm (1.6 mW) and for ANT is 2.0 dBm (1.6 mW). Therefore, if the BLE transmitter is excluded, the ANT transmitter would also be excluded. The calculations are listed below.

For the FCC, the exclusion is based on the formula listed in 47 CFR 1.1310. For body, the exclusion limit is 3 mW and for extremity, it is 2.5 times the body limit which is 7.5 mW.

For ISED, the limit is based on Table 1 in RSS-102 Issue 5 section 2.5.1. The table numbers are multiplied by 2.5 for extremity devices. Therefore, the maximum power for the transmitters are 17.5 mW to be excluded. The maximum power for the transmitters is 3.2 mW which is below the 17.5 mW limit.

The 13.56 MHz band has a transmit power of less the 1 mW which is categorically excluded from SAR testing for both the FCC and ISED.

The device was on a minimum of 10 cm of Styrofoam during each test.

**Table 8.1 Test Reduction Table**

Mode	Side	Required Channel	Tested/Reduced
802.11b	Back	1 – 2412 MHz	Tested
		6 – 2437 MHz	Tested
		11 – 2462 MHz	Tested
	All Other Sides	1 – 2412 MHz	Reduced <sup>3</sup>
		6 – 2437 MHz	Reduced <sup>3</sup>
		11 – 2462 MHz	Reduced <sup>3</sup>
802.11g	Back	1 – 2412 MHz	Reduced <sup>2</sup>
		6 – 2437 MHz	Reduced <sup>2</sup>
		11 – 2462 MHz	Reduced <sup>2</sup>
	All Other Sides	1 – 2412 MHz	Reduced <sup>3</sup>
		6 – 2437 MHz	Reduced <sup>3</sup>
		11 – 2462 MHz	Reduced <sup>3</sup>
802.11n	Back	1 – 2412 MHz	Reduced <sup>2</sup>
		6 – 2437 MHz	Reduced <sup>2</sup>
		11 – 2462 MHz	Reduced <sup>2</sup>
	All Other Sides	1 – 2412 MHz	Reduced <sup>3</sup>
		6 – 2437 MHz	Reduced <sup>3</sup>
		11 – 2462 MHz	Reduced <sup>3</sup>

Reduced<sup>1</sup> – When the reported SAR is >1.0 W/kg, test the next highest configuration until the SAR value is ≤ 2.0 W/kg per KDB 248227 D01 v02r02 section 5.1.1 2) page 9.

Reduced<sup>2</sup> – When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 3.0 W/kg, SAR is not required per KDB 248227 D01 v02r02 section 5.2.2 2) page 10.

Reduced<sup>3</sup> - The remaining sides are not used next to the body.

Mode	Side	Required Channel	Tested/Reduced
BT Classic	Back	0 – 2402 MHz	Tested
		39 – 2441 MHz	Tested
		78 – 2480 MHz	Tested
	All Other Sides	0 – 2402 MHz	Reduced <sup>3</sup>
		39 – 2441 MHz	Reduced <sup>3</sup>
		78 – 2480 MHz	Reduced <sup>3</sup>
BLE	Back	0 – 2404 MHz	Reduced <sup>2</sup>
		17 – 2441 MHz	Reduced <sup>2</sup>
		36 – 2478 MHz	Reduced <sup>2</sup>
	All Other Sides	0 – 2404 MHz	Reduced <sup>2</sup>
		17 – 2441 MHz	Reduced <sup>2</sup>
		36 – 2478 MHz	Reduced <sup>2</sup>
ANT	Back	0 – 2402 MHz	Reduced <sup>2</sup>
		39 – 2441 MHz	Reduced <sup>2</sup>
		78 – 2480 MHz	Reduced <sup>2</sup>
	All Other Sides	0 – 2402 MHz	Reduced <sup>2</sup>
		39 – 2441 MHz	Reduced <sup>2</sup>
		78 – 2480 MHz	Reduced <sup>2</sup>

Reduced<sup>1</sup> – When the reported SAR is >1.0 W/kg, test the next highest configuration until the SAR value is ≤ 2.0 W/kg per KDB 248227 D01 v02r02 section 5.1.1 2) page 9.

Reduced<sup>2</sup> – The transmitter is excluded per KDB447498 D01 v06 section 4.3.1 a) on page 12. See calculation on page 23 of this report.

Reduced<sup>3</sup> - The remaining sides are not used next to the body.

Band	Mode	Bandwidth (MHz)	Channel	Frequency (MHz)	Data Rate	Avg Power (dBm)	Tune-up Pwr (dBm)
2450 MHz	802.11b	20	1	2412	1 Mbps	15.34	18.00
			6	2437		17.68	18.00
			11	2462		13.93	18.00
	802.11g	20	1	2412	6 Mbps	Not Required	15.00
			6	2437			15.00
			11	2462			15.00
	802.11n	20	1	2412	HT0		15.00
			6	2437			15.00
			11	2462			15.00

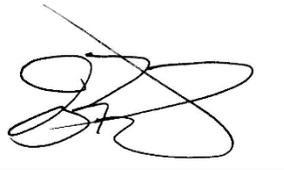
Band	Mode	Channel	Frequency (MHz)	Avg Power (dBm)	Tune-up Pwr (dBm)
2450 MHz	BT Classic	1	2402	9.86	10.50
		39	2440	10.19	10.50
		78	2480	9.98	10.50
	BLE	0	2404	Not Required	2.00
		17	2440		2.00
		36	2478		2.00
	ANT	1	2402		2.00
		39	2440		2.00
		78	2480		2.00

**SAR Data Summary – 2450 MHz Extremity 802.11b & BT Classic**

MEASUREMENT RESULTS								
Plot	Gap	Position	Frequency		Modulation	End Power (dBm)	Measured SAR (W/kg)	Reported SAR (W/kg)
			MHz	Ch.				
-----	0 mm	Back	2412	1	DSSS	15.34	0.522	0.96
1			2437	6	DSSS	17.68	0.892	0.96
-----			2462	11	DSSS	13.93	0.336	0.86
-----		Back	2402	1	BTBR	9.86	0.215	0.25
-----			2440	39	BTBR	10.19	0.265	0.29
-----			2480	78	BTBR	9.98	0.204	0.23
-----								

**Extremity**  
**4.0 W/kg (mW/g)**  
 averaged over 10 gram

1. Battery is fully charged for all tests.  
 Power Measured  Conducted  ERP  EIRP
2. SAR Measurement  
 Phantom Configuration  Left Head  Eli4  Right Head  
 SAR Configuration  Head  Body
3. Test Signal Call Mode  Test Code  Base Station Simulator
4. Test Configuration  With Belt Clip  Without Belt Clip  N/A
5. Tissue Depth is at least 15.0 cm



Jay M. Moulton  
 Vice President

## 9. Test Equipment List

**Table 9.1 Equipment Specifications**

Type	Calibration Due Date	Calibration Done Date	Serial Number
Staubli Robot TX60L	N/A	N/A	F07/55M6A1/A/01
Measurement Controller CS8c	N/A	N/A	1012
ELI5 Flat Phantom	N/A	N/A	2037
Device Holder	N/A	N/A	N/A
Data Acquisition Electronics 4	04/12/2023	04/12/2022	1416
SPEAG E-Field Probe EX3DV4	02/16/2023	02/16/2022	3662
Speag Validation Dipole D2450V2	06/03/2023	06/03/2021	881
Agilent N1911A Power Meter	03/16/2023	03/16/2022	GB45100254
Agilent N1922A Power Sensor	03/17/2023	03/17/2022	MY45240464
Agilent (HP) 8561E Spectrum Analyzer	03/17/2023	03/17/2022	31720068
Agilent (HP) 83752A Synthesized Sweeper	03/17/2023	03/17/2022	3610A01048
Agilent (HP) 8753C Vector Network Analyzer	03/17/2023	03/17/2022	3135A01724
Agilent (HP) 85047A S-Parameter Test Set	03/16/2023	03/16/2022	2904A00595
Agilent 778D Dual Directional Coupler	N/A	N/A	MY48220184
MiniCircuits BW-N20W5+ Fixed 20 dB Attenuator	N/A	N/A	N/A
MiniCircuits SPL-10.7+ Low Pass Filter	N/A	N/A	R8979513746
Apriel Dielectric Probe Assembly	N/A	N/A	0011
Head Equivalent Matter (2450 MHz)	N/A	N/A	N/A

## 10. Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC/IC. These measurements are taken to simulate the RF effects exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body is a very complex phenomena that depends on the mass, shape, and size of the body; the orientation of the body with respect to the field vectors; and, the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables. [3]

## 11. References

- [1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radio Frequency Radiation, August 1996
- [2] ANSI/IEEE C95.1 – 1992, American National Standard Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300kHz to 100GHz, New York: IEEE, 1992.
- [3] ANSI/IEEE C95.3 – 1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave, New York: IEEE, 1992.
- [4] International Electrotechnical Commission, IEC 62209-2 (Edition 1.0), Human Exposure to radio frequency fields from hand-held and body mounted wireless communication devices – Human models, instrumentation, and procedures – Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz), March 2010.
- [5] IEEE Standard 1528 – 2013, IEEE Recommended Practice for Determining the Peak-Spatial Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, June 2013.
- [6] Industry Canada, RSS – 102 Issue 5 Draft, Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), March 2014.
- [7] Health Canada, Safety Code 6, Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz, 2009.

## Appendix A – System Validation Plots and Data

```
*****  
Test Result for UIM Dielectric Parameter  
Mon 14/Nov/2022  
Freq   Frequency(GHz)  
FCC_eH Limits for Head Epsilon  
FCC_sH Limits for Head Sigma  
Test_e Epsilon of UIM  
Test_s Sigma of UIM  
*****  
Freq           FCC_eH FCC_sH Test_e Test_s  
2.4000         39.27  1.75   38.79  1.76  
2.4020         39.268 1.752  38.786 1.762*  
2.4100         39.26  1.76   38.77  1.77  
2.4120         39.258 1.762  38.766 1.772*  
2.4200         39.25  1.77   38.75  1.78  
2.4300         39.24  1.78   38.73  1.79  
2.4370         39.226 1.787  38.723 1.804*  
2.4400         39.22  1.79   38.72  1.81  
2.4410         39.218 1.791  38.715 1.811*  
2.4420         39.216 1.792  38.71  1.812*  
2.4500         39.20  1.80   38.67  1.82  
2.4600         39.19  1.81   38.67  1.83  
2.4620         39.186 1.812  38.666 1.832*  
2.4700         39.17  1.82   38.65  1.84  
2.4800         39.16  1.83   38.63  1.87
```

\* value interpolated

# RF Exposure Lab

## Plot 1

**DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN: 881**

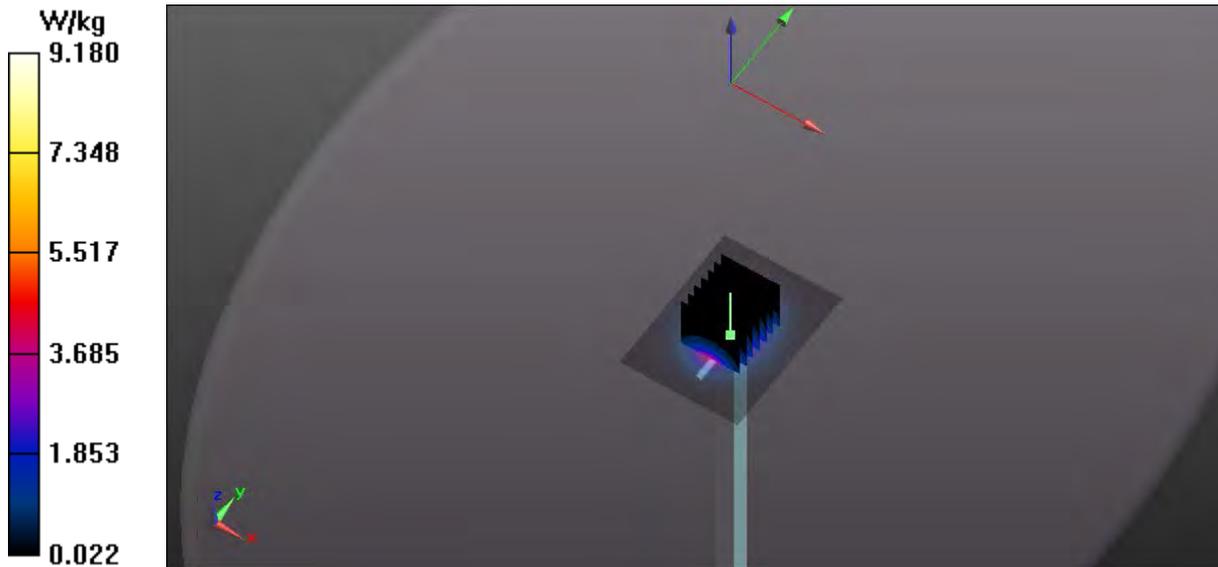
Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1  
Medium: HSL2450; Medium parameters used:  $f = 2450 \text{ MHz}$ ;  $\sigma = 1.82 \text{ S/m}$ ;  $\epsilon_r = 38.67$ ;  $\rho = 1000 \text{ kg/m}^3$   
Phantom section: Flat Section

Test Date: Date: 11/14/2022; Ambient Temp: 23 °C; Tissue Temp: 21 °C  
Probe: EX3DV4 – SN3662; ConvF(7.28, 7.28, 7.28); Calibrated: 2/16/2022;  
Sensor-Surface: 2mm (Mechanical Surface Detection)  
Electronics: DAE4 Sn1416; Calibrated: 4/12/2022  
Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 2037  
Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

### Procedure Notes:

**Head Verification/2450 MHz/Area Scan (61x101x1):** Interpolated grid:  $dx=1.200 \text{ mm}$ ,  $dy=1.200 \text{ mm}$   
Maximum value of SAR (interpolated) = 9.18 W/kg

**Head Verification/2450 MHz/Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$   
Reference Value = 54.541 V/m; Power Drift = -0.02 dB  
Peak SAR (extrapolated) = 11.5 W/kg  
 $P_{in} = 100 \text{ mW}$   
**SAR(1 g) = 5.48 W/kg; SAR(10 g) = 2.51 W/kg**  
Maximum value of SAR (measured) = 8.98 W/kg



## **Appendix B – SAR Test Data Plots**

# RF Exposure Lab

## Plot 1

**DUT: A04452; Type: Wrist Watch; Serial: 426283464**

Communication System: WiFi 802.11b (DSSS, 1 Mbps); Frequency: 2437 MHz; Duty Cycle: 1:1  
Medium: HSL2450; Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.804$  S/m;  $\epsilon_r = 38.723$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section

Test Date: Date: 11/14/2022; Ambient Temp: 23 °C; Tissue Temp: 21 °C

Probe: EX3DV4 - SN3662; ConvF(7.28, 7.28, 7.28); Calibrated: 2/16/2022  
Sensor-Surface: 2mm (Mechanical Surface Detection)  
Electronics: DAE4 Sn1416; Calibrated: 4/12/2022  
Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 2037  
Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

### Procedure Notes:

**WiFi/Back Mid 6/Area Scan (10x10x1):** Measurement grid: dx=10mm, dy=10mm

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 2.69 W/kg

**WiFi/Back Mid 6/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

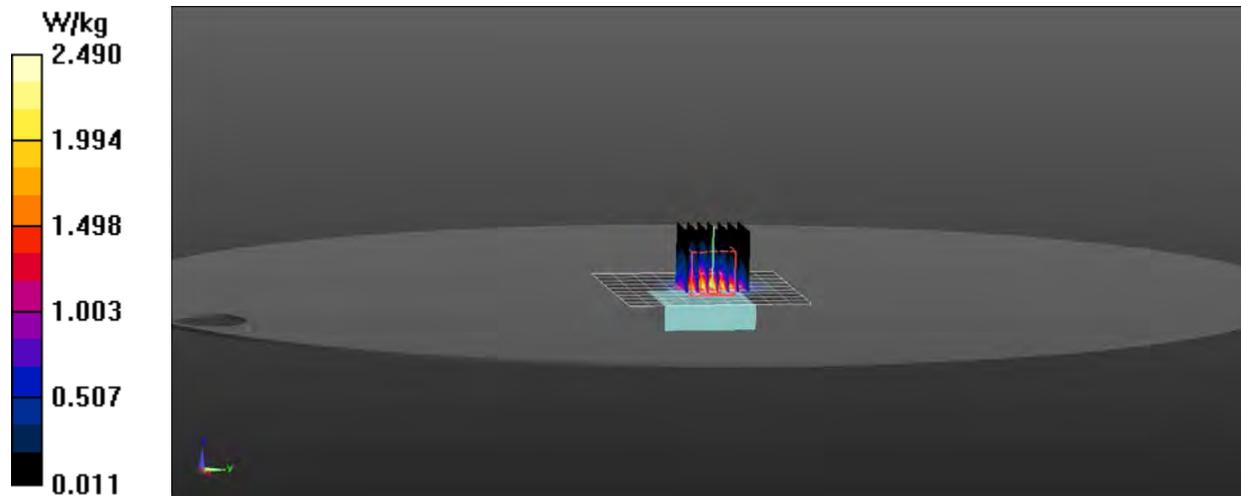
Reference Value = 35.31 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 3.25 W/kg

**SAR(1 g) = 1.81 W/kg; SAR(10 g) = 0.892 W/kg**

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 2.49 W/kg



## Appendix D – Probe Calibration Data Sheets



Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **RF Exposure Lab**

Certificate No: **EX3-3662\_Feb22**

## CALIBRATION CERTIFICATE

Object: **EX3DV4 - SN:3662**

Calibration procedure(s): **QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v6, QA CAL-23.v5,  
QA CAL-25.v7  
Calibration procedure for dosimetric E-field probes**

Calibration date: **February 16, 2022**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: CC2552 (20x)	09-Apr-21 (No. 217-03343)	Apr-22
DAE4	SN: 660	13-Oct-21 (No. DAE4-660_Oct21)	Oct-22
Reference Probe ES3DV2	SN: 3013	27-Dec-21 (No. ES3-3013_Dec21)	Dec-22
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-20)	In house check: Jun-22
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Sven Kühn</b>	Deputy Manager	

Issued: February 18, 2022

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Accreditation No.: **SCS 0108**

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### Glossary:

TSL	tissue simulating liquid
NORM <sub>x,y,z</sub>	sensitivity in free space
ConvF	sensitivity in TSL / NORM <sub>x,y,z</sub>
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\vartheta$	$\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

### Calibration is Performed According to the Following Standards:

- IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E<sup>2</sup>-field uncertainty inside TSL (see below *ConvF*).
- NORM(f)<sub>x,y,z</sub>** = NORM<sub>x,y,z</sub> \* *frequency\_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- DCP<sub>x,y,z</sub>**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>; A, B, C, D** are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for  $f \leq 800$  MHz) and inside waveguide using analytical field distributions based on power measurements for  $f > 800$  MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM<sub>x,y,z</sub> \* *ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from  $\pm 50$  MHz to  $\pm 100$  MHz.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM<sub>x</sub> (no uncertainty required).

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3662

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.42	0.49	0.48	$\pm 10.1 \%$
DCP (mV) <sup>B</sup>	99.8	99.6	98.2	

### Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Max dev.	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	147.3	$\pm 2.7 \%$	$\pm 4.7 \%$
		Y	0.0	0.0	1.0		161.3		
		Z	0.0	0.0	1.0		168.0		

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k=2$ , which for a normal distribution corresponds to a coverage probability of approximately 95%.

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Pages 5 and 6).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3662

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-94.7
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

**Note:** Measurement distance from surface can be increased to 3-4 mm for an *Area Scan* job.

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3662

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
150	52.3	0.76	11.58	11.58	11.58	0.00	1.00	± 13.3 %
220	49.0	0.81	11.43	11.43	11.43	0.00	1.00	± 13.3 %
300	45.3	0.87	11.15	11.15	11.15	0.09	1.00	± 13.3 %
450	43.5	0.87	10.72	10.72	10.72	0.16	1.30	± 13.3 %
750	41.9	0.89	9.23	9.23	9.23	0.52	0.80	± 12.0 %
900	41.5	0.97	8.76	8.76	8.76	0.44	0.80	± 12.0 %
1450	40.5	1.20	8.18	8.18	8.18	0.37	0.80	± 12.0 %
1640	40.2	1.31	8.03	8.03	8.03	0.35	0.86	± 12.0 %
1750	40.1	1.37	7.87	7.87	7.87	0.32	0.86	± 12.0 %
1900	40.0	1.40	7.66	7.66	7.66	0.27	0.86	± 12.0 %
2300	39.5	1.67	7.54	7.54	7.54	0.34	0.90	± 12.0 %
2450	39.2	1.80	7.28	7.28	7.28	0.38	0.90	± 12.0 %
2600	39.0	1.96	7.10	7.10	7.10	0.38	0.90	± 12.0 %
3500	37.9	2.91	6.73	6.73	6.73	0.35	1.30	± 13.1 %
3700	37.7	3.12	6.53	6.53	6.53	0.35	1.30	± 13.1 %
5250	35.9	4.71	4.95	4.95	4.95	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.66	4.66	4.66	0.40	1.80	± 13.1 %
5750	35.4	5.22	4.80	4.80	4.80	0.40	1.80	± 13.1 %

<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3662

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
6500	34.5	6.07	5.50	5.50	5.50	0.20	2.00	± 18.6 %

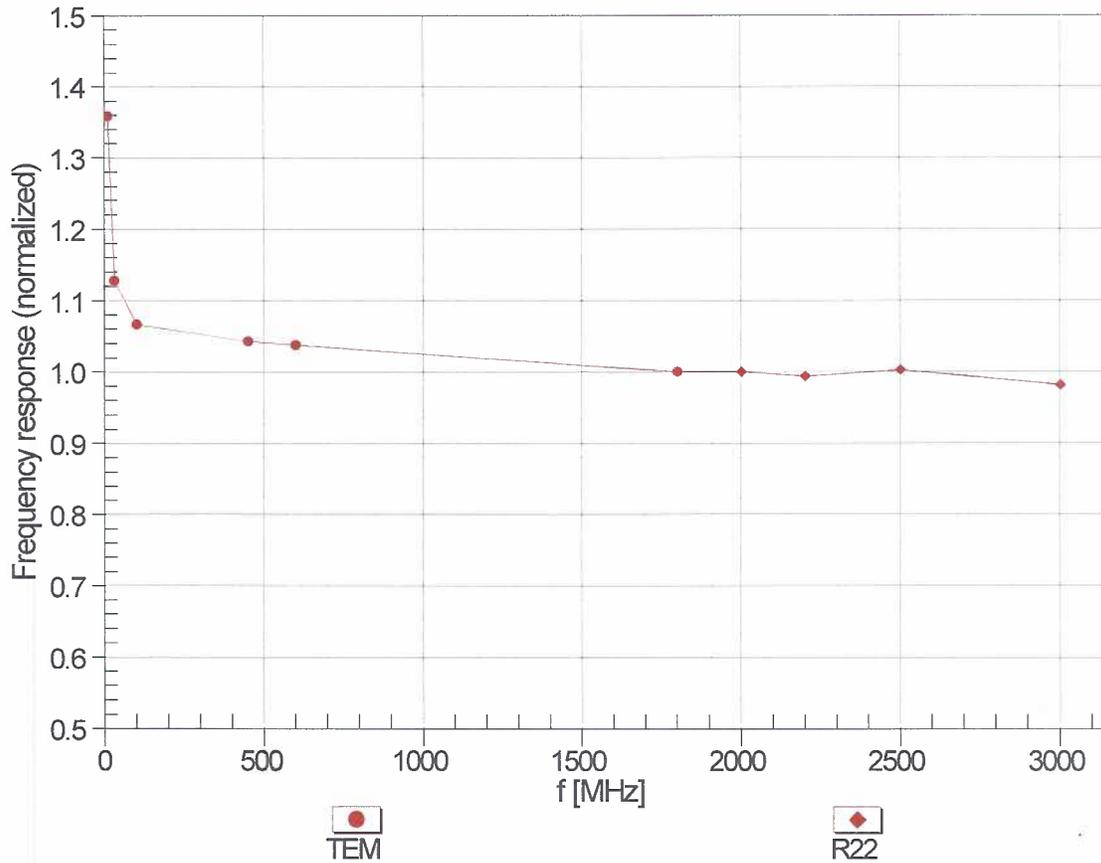
<sup>C</sup> Frequency validity above 6GHz is ± 700 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

<sup>F</sup> At frequencies 6-10 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz; below ± 2% for frequencies between 3-6 GHz; and below ± 4% for frequencies between 6-10 GHz at any distance larger than half the probe tip diameter from the boundary.

# Frequency Response of E-Field

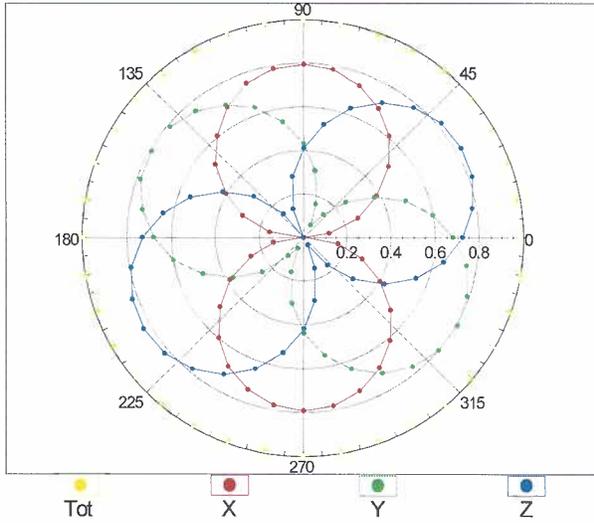
(TEM-Cell:ifi110 EXX, Waveguide: R22)



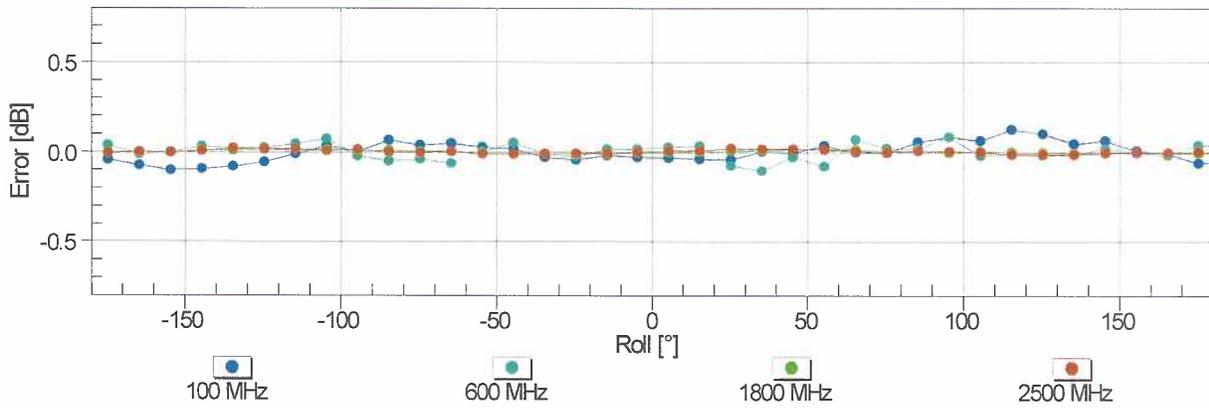
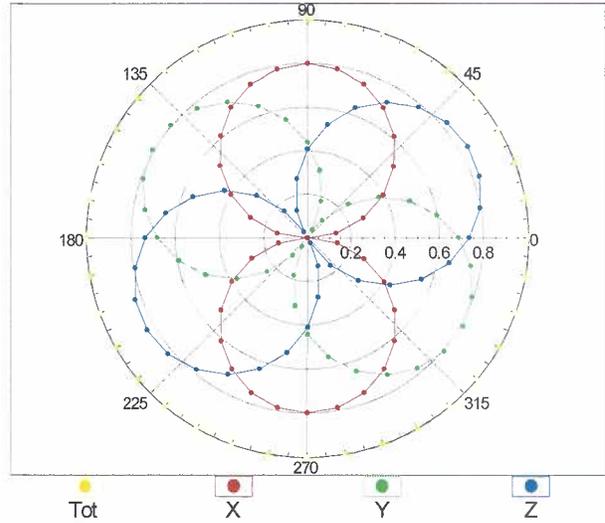
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

# Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$

f=600 MHz, TEM

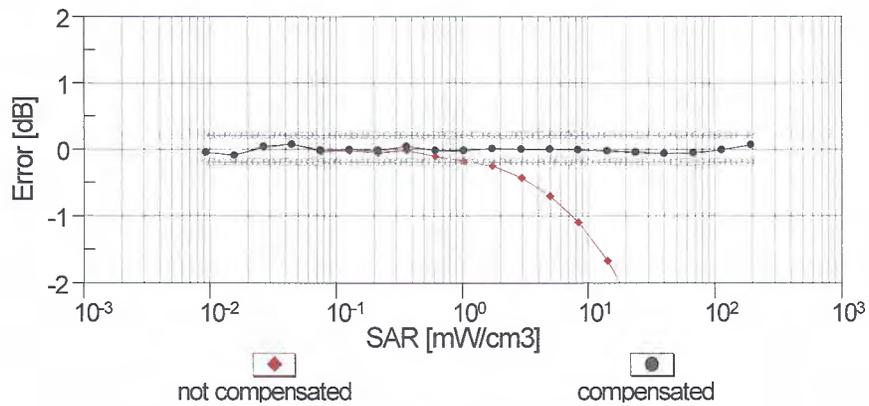
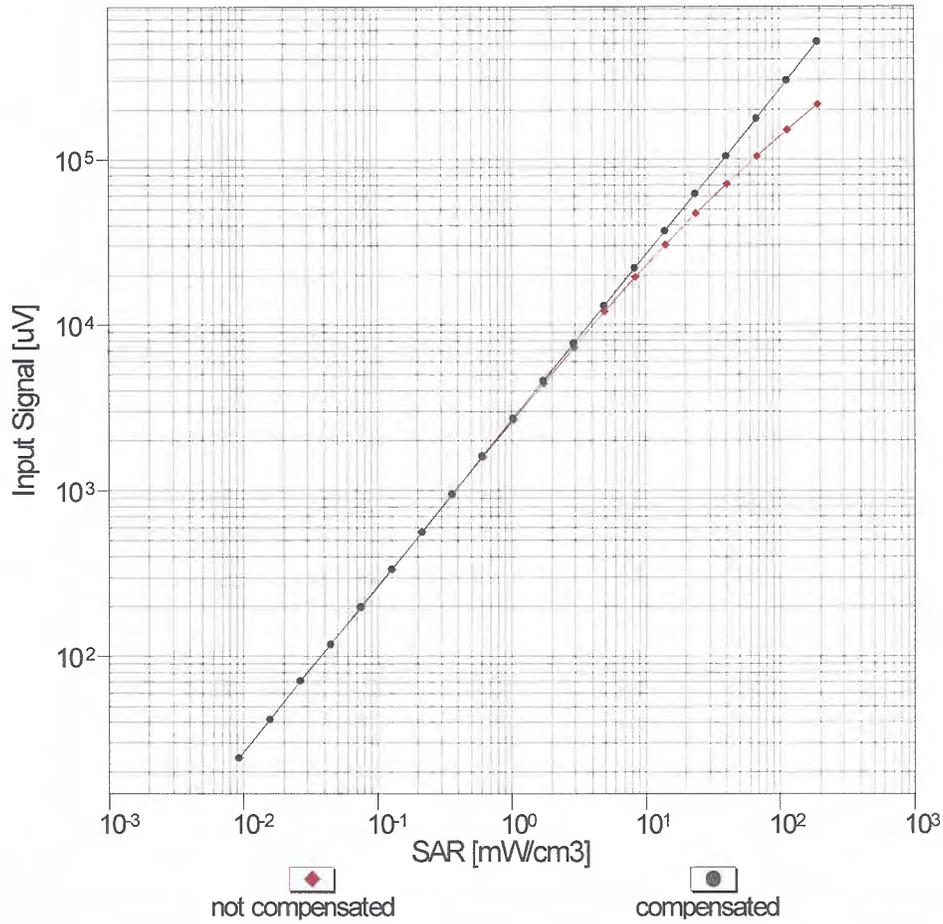


f=1800 MHz, R22



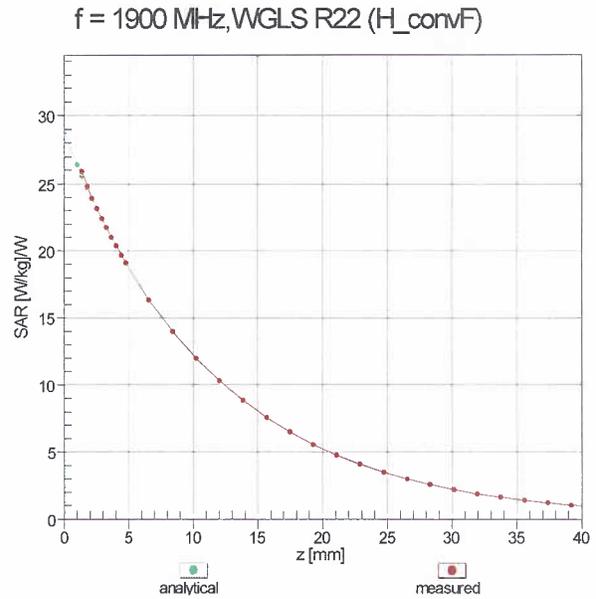
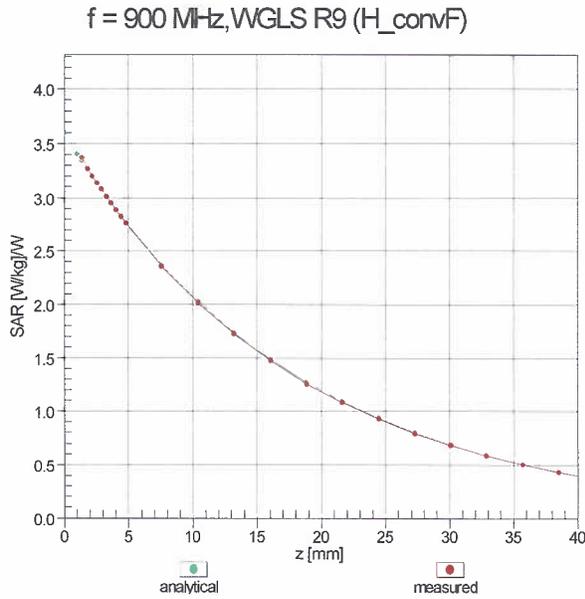
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

## Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )

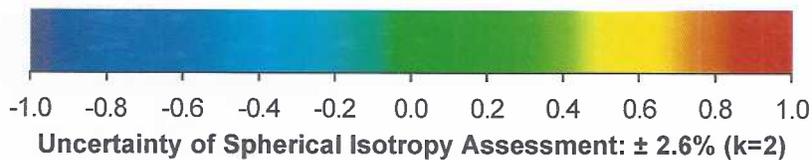
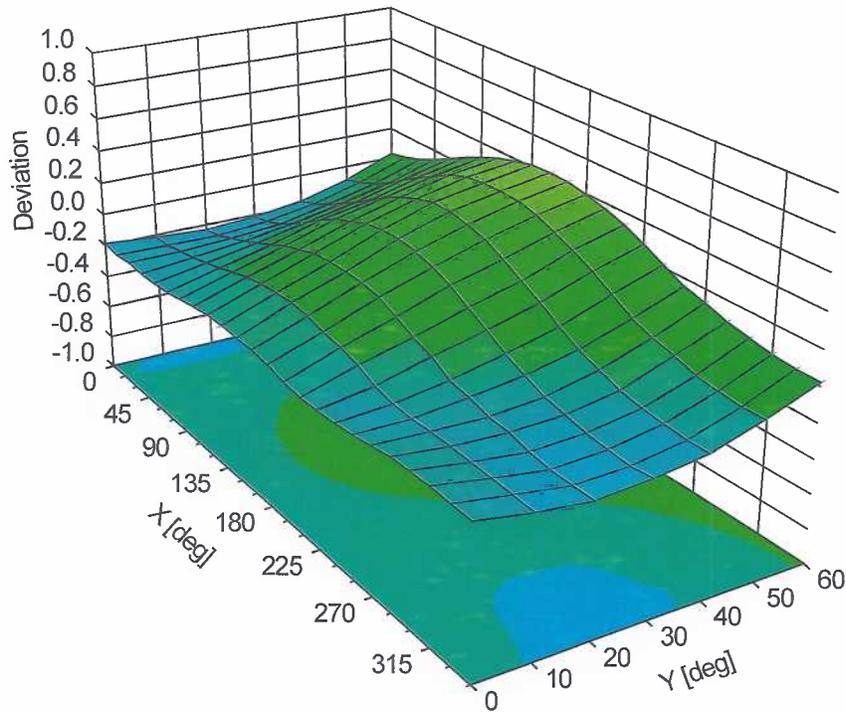


**Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )**

# Conversion Factor Assessment



## Deviation from Isotropy in Liquid Error ( $\phi, \vartheta$ ), f = 900 MHz



## **Appendix E – Dipole Calibration Data Sheets**

*Jm*

**Calibration Laboratory of  
Schmid & Partner  
Engineering AG**  
Zeughausstrasse 43, 8004 Zurich, Switzerland



**S** Schweizerischer Kalibrierdienst  
**C** Service suisse d'étalonnage  
**S** Servizio svizzero di taratura  
**S** Swiss Calibration Service

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**Accreditation No.: SCS 0108**

Client **RF Exposure Lab**

Certificate No: **D2450V2-881\_Jun21**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN:881**

Calibration procedure(s) **QA CAL-05 v11  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **June 03, 2021**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7349	28-Dec-20 (No. EX3-7349_Dec20)	Dec-21
DAE4	SN: 601	02-Nov-20 (No. DAE4-601_Nov20)	Nov-21

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

	Name	Function	Signature
Calibrated by:	Jeffrey Katzman	Laboratory Technician	<i>J. Katzman</i>

Approved by:	Katja Pokovic	Technical Manager	<i>K. Pokovic</i>
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Issued: June 8, 2021

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### Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

### Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured:** SAR measured at the stated antenna input power.
- SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k=2$ , which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

<b>DASY Version</b>	DASY5	V52.10.4
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2450 MHz ± 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.2	1.80 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	37.7 ± 6 %	1.87 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	13.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>54.1 W/kg ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>25.0 W/kg ± 16.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.3 $\Omega$ + 4.3 j $\Omega$
Return Loss	- 24.7 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.156 ns
----------------------------------	----------

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

Manufactured by	SPEAG
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#### Extended Calibration

Usage of SAR dipoles calibrated less than 3 years ago but more than 1 year ago were confirmed in maintaining return loss (<-20 dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB Publication 865664 D01 v01r04.

D2450V2 SN: 829 - Head						
Date of Measurement	Return Loss (dB)	$\Delta\%$	Impedance Real ( $\Omega$ )	$\Delta\Omega$	Impedance Imaginary (j $\Omega$ )	$\Delta\Omega$
6/3/2021	-24.7		54.3		4.3	
6/3/2022	-25.3	2.4	55.2	0.9	4.1	-0.2

## DASY5 Validation Report for Head TSL

Date: 03.06.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:881**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.87$  S/m;  $\epsilon_r = 37.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 119.0 V/m; Power Drift = 0.05 dB

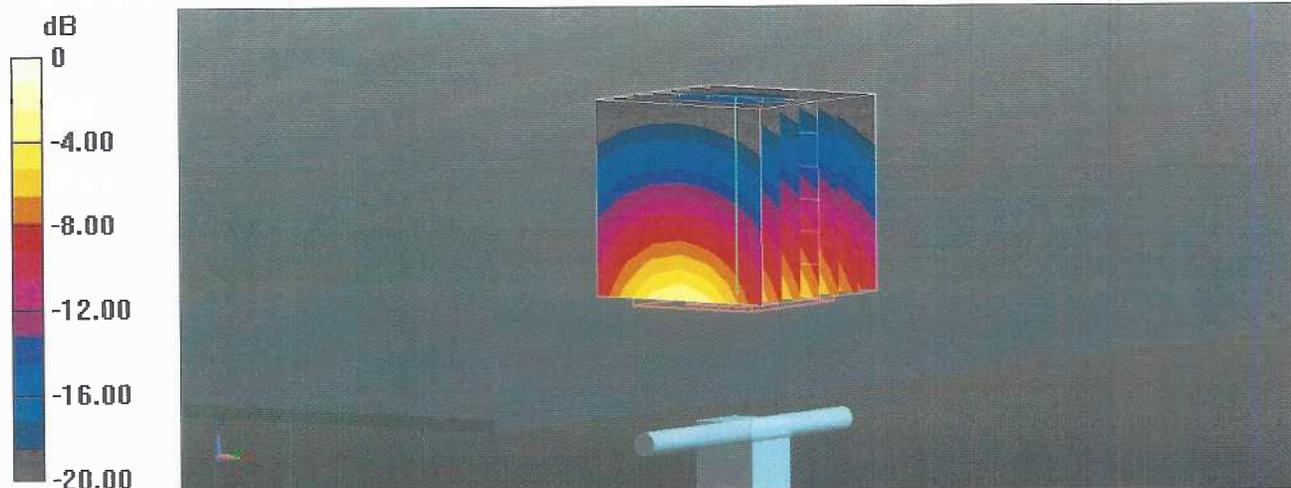
Peak SAR (extrapolated) = 28.0 W/kg

**SAR(1 g) = 13.9 W/kg; SAR(10 g) = 6.34 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

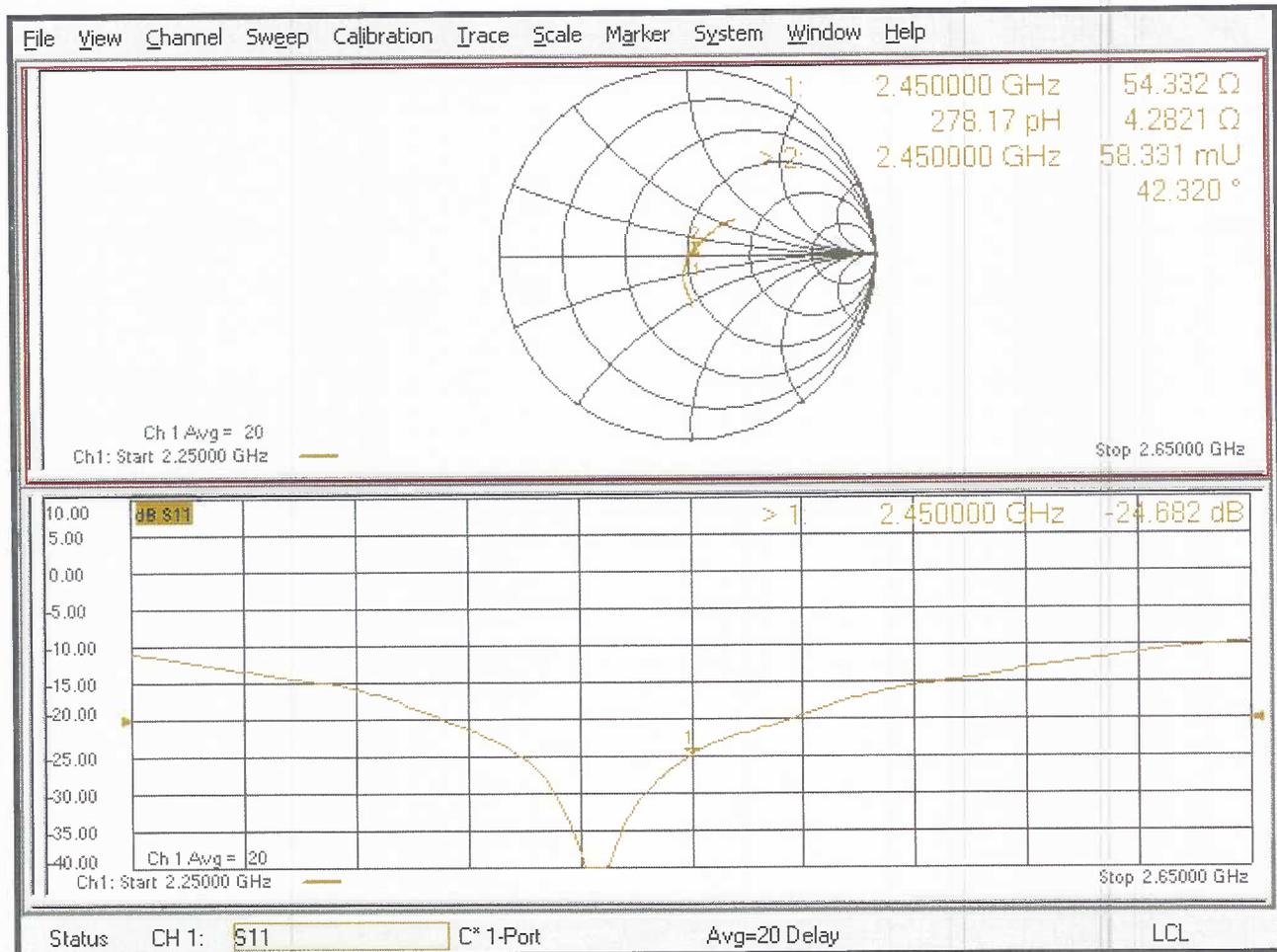
Ratio of SAR at M2 to SAR at M1 = 49.5%

Maximum value of SAR (measured) = 23.1 W/kg



0 dB = 23.1 W/kg = 13.64 dBW/kg

# Impedance Measurement Plot for Head TSL



## **Appendix F – DAE Calibration Data Sheets**



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **RF Exposure Lab**

Certificate No: **DAE4-1416\_Apr22**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 1416**

Calibration procedure(s) **QA CAL-06.v30**  
**Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **April 12, 2022**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	31-Aug-21 (No:31368)	Aug-22
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	24-Jan-22 (in house check)	In house check: Jan-23
Calibrator Box V2.1	SE UMS 006 AA 1002	24-Jan-22 (in house check)	In house check: Jan-23

Calibrated by: **Name** Adrian Gehring **Function** Laboratory Technician

Approved by: **Name** Sven Kühn **Deputy Manager**

Signature

Issued: April 12, 2022

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Accreditation No.: **SCS 0108**

## Glossary

**DAE** data acquisition electronics  
**Connector angle** information used in DASY system to align probe sensor X to the robot coordinate system.

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ V, full range = -100...+300 mV

Low Range: 1LSB = 61nV, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	403.562 $\pm$ 0.02% (k=2)	403.870 $\pm$ 0.02% (k=2)	404.137 $\pm$ 0.02% (k=2)
Low Range	3.97865 $\pm$ 1.50% (k=2)	3.99513 $\pm$ 1.50% (k=2)	3.97046 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	107.5 $^{\circ}$ $\pm$ 1 $^{\circ}$
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	199993.69	0.39	0.00
Channel X + Input	20001.91	0.04	0.00
Channel X - Input	-20001.32	0.29	-0.00
Channel Y + Input	199995.49	2.37	0.00
Channel Y + Input	20001.59	-0.18	-0.00
Channel Y - Input	-20002.90	-1.28	0.01
Channel Z + Input	199997.14	3.84	0.00
Channel Z + Input	20000.35	-1.29	-0.01
Channel Z - Input	-20003.32	-1.40	0.01

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	2001.25	0.20	0.01
Channel X + Input	201.83	0.41	0.20
Channel X - Input	-198.42	0.20	-0.10
Channel Y + Input	2000.98	-0.02	-0.00
Channel Y + Input	200.80	-0.47	-0.23
Channel Y - Input	-199.14	-0.51	0.25
Channel Z + Input	2000.99	0.08	0.00
Channel Z + Input	200.25	-0.91	-0.45
Channel Z - Input	-200.06	-1.29	0.65

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading ( $\mu\text{V}$ )	Low Range Average Reading ( $\mu\text{V}$ )
Channel X	200	-3.28	-4.95
	-200	6.21	4.15
Channel Y	200	-6.92	-7.58
	-200	6.27	6.10
Channel Z	200	-23.61	-23.40
	-200	21.76	21.65

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X ( $\mu\text{V}$ )	Channel Y ( $\mu\text{V}$ )	Channel Z ( $\mu\text{V}$ )
Channel X	200	-	2.55	-3.59
Channel Y	200	7.33	-	2.96
Channel Z	200	8.86	6.81	-

#### 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	15996	17631
Channel Y	16152	16767
Channel Z	16134	15846

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10M $\Omega$

	Average ( $\mu$ V)	min. Offset ( $\mu$ V)	max. Offset ( $\mu$ V)	Std. Deviation ( $\mu$ V)
Channel X	0.76	-0.27	1.42	0.33
Channel Y	-0.76	-2.04	0.57	0.45
Channel Z	-0.41	-1.10	0.34	0.30

#### 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

#### 7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

#### 8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

#### 9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9

## **Appendix G – Phantom Calibration Data Sheets**

**Certificate of Conformity / First Article Inspection**

Item	Oval Flat Phantom ELI 4.0
Type No	QD OVA 001 B
Series No	1003 and higher
Manufacturer	Untersee Composites Knebelstrasse 8 CH-8268 Mannenbach, Switzerland

**Tests**

Complete tests were made on the prototype units QD OVA 001 AA 1001, QD OVA 001 AB 1002, pre-series units QD OVA 001 BA 1003-1005 as well as on the series units QD OVA 001 BB, 1006 ff.

Test	Requirement	Details	Units tested
Material thickness	Compliant with the standard requirements	Bottom plate: 2.0mm +/- 0.2mm	all
Material parameters	Dielectric parameters for required frequencies	< 6 GHz: Rel. permittivity = 4 +/-1, Loss tangent ≤ 0.05	Material sample
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards if handled and cleaned according to the instructions.	DGBE based simulating liquids. Observe Technical Note for material compatibility.	Equivalent phantoms, Material sample
Shape	Thickness of bottom material, Internal dimensions, Sagging compatible with standards from minimum frequency	Bottom elliptical 600 x 400 mm Depth 190 mm, Shape is within tolerance for filling height up to 155 mm, Eventual sagging is reduced or eliminated by support via DUT	Prototypes, Sample testing

**Standards**

- [1] CENELEC EN 50361-2001, « Basic standard for the measurement of the Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz) », July 2001
- [2] IEEE 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques, December 2003
- [3] IEC 62209 – 1, "Specific Absorption Rate (SAR) in the frequency range of 300 MHz to 3 GHz – Measurement Procedure, Part 1: Hand-held mobile wireless communication devices", February 2005
- [4] IEC 62209 – 2, Draft, "Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices – Human models, Instrumentation and Procedures – Part 2: Procedure to determine the Specific Absorption Rate (SAR) in the head and body for 30 MHz to 6 GHz Handheld and Body-Mounted Devices used in close proximity to the Body.", February 2005
- [5] OET Bulletin 65, Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition January 2001

Based on the tests above, we certify that this item is in compliance with the standards [1] to [5] if operated according to the specific requirements and considering the thickness. The dimensions are fully compliant with [4] from 30 MHz to 6 GHz. For the other standards, the minimum lower frequency limit is limited due to the dimensional requirements ([1]: 450 MHz, [2]: 300 MHz, [3]: 800 MHz, [5]: 375 MHz) and possibly further by the dimensions of the DUT.

Date 28.4.2008 Signature / Stamp

**s p e a g**  
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